Pushbutton-operated windscreen wiper controller

Windscreen wipers always wipe either too frequently or not frequently enough. This is a corollary of Murphy's law. Vehicle engineers have spent much creative thought and effort on solving this problem since vehicles had windscreens and covered cabins. Knobs and switches abound. This one simply requires a push or two on some buttons and gives you the exact wiping frequency you need.

Geoff Nicholls
Roger Harrison

THE CIRCUIT for this project won the 'Idea of the Month' contest, sponsored by Scope Laboratories, for the September 1982 issue. A reader from Herston in Queensland, who only wished to be identified as J.D.W., submitted the circuit. It is probably one of the most intriguing circuits ever submitted for the contest. Not only that, it solved a practical problem in an elegant and intriguing way.

As the introduction says, windscreen wipers either wipe too frequently, or not frequently enough. As most late-model cars are fitted with dual-speed wipers, at high speed they're making setting-teeth-on-edge noises after half a dozen wipes in the high speed position or not getting rid of the water fast enough in the slow speed position, in any given downpour.

Vehicle manufacturers, in our opinion (and experience), have never adequately addressed themselves to the problem. Two-speed wiper systems are legion. And what driver of a vehicle with a two-speed wiper has *not* mentally labelled the two speeds 'too slow' and 'too fast'.

A 'fully variable' system has long been considered the best solution. With these a rotary control provides a variation in wiper speed from a wipe every few seconds to a few wipes per second (maximum motor speed). That's fine, but you have to mentally 'calibrate' the control. At slow wiping speeds, this is a difficult task and you spend some considerable time fiddling with the control. Inevitably, you give up and take the 'that'll do' line of least resistance.

Let us examine what happens when you're driving along and it starts to rain. First thing, the windscreen gets wet. When it gets wet enough, you want it wiped. You start the wiper and it does its job. Some interval later, the windscreen gets wet enough that you want it wiped again. *That's* the interval at which the wipers should operate. How on earth does one design a control that does that? The answer is, you don't. What you need is a controller with a 'memory'. Press a button to wipe the windscreen when it first gets too wet for you, then press it again when the windscreen next gets too wet, and have the controller repeat the wipes at the same interval. That's what the memory does — remembers the interval between the first two wipes.

What to do when the rain increases? Simply press the button again between wipes, setting a new interval. How do you stop it when the rain stops? — simple, have a stop button!

What to do when the rain decreases? Aahh — thought you'd ask that. Hit the stop button, but keep the memory going, then start the wipers again when the windscreen gets too wet, repeating the wipes at the interval between the last wipe and the new one.

That's exactly what this project does.

There's one final question to resolve, however. How long should the 'memory' be? Our correspondent set it at about 40 seconds. From observation, this seems about right. Driving in intermittent rain, we observed that the maximum interval between successive 'too wet' windscreens was about 30 seconds. During the latter half of 1982, Sydney turned on some very Melbourne-like weather — intermittent rain and shine, very light, 'patchy' rain, etc. The Editor cursed his dual-speed wiper and yearned for something better. Hence, this project.

The circuit employs half a dozen ICs, two transistors, a handful of capacitors and around 30 resistors. A relay is used to control the operation of the wiper motors.

Before going on with the construction, let us take a look at the wiper systems in modern vehicles.

Wiper systems

With rare exceptions, windscreen wipers on modern vehicles are driven by an electric motor. Two motor types are employed — permanent magnet motors and wound field motors. The wiper systems are generally arranged so that the wipers are 'parked' out of the field of view when they're not in use. A cam-operated switch effects this, turning off the wiper motor only when the wipers are in the appropriate position and the supply to the motors is cut. However, the two different motor types have different braking characteristics when the motor supply is cut, so different switch schemes are used for parking.

Wound field motors simply have the supply cut when the wipers are in the appropriate position. A set of cam-operated contacts on the drive shaft effects this. Figure 1 shows how the arrangement works. The cam opens the contacts when the wipers are in the parked position. The wiper switch parallels the cam contacts. When you turn the wiper switch to the off position, the motor will continue until the cam contacts open.

Permanent magnet motors have 'dynamic braking' applied. A short circuit is connected across the motor armature when the wipers reach the parked position. The circuit is shown in Figure 2. Cam-operated changeover contacts are connected such that, when the wiper switch is set to the off position, the cam contacts short the armature. When power to the motor is cut, it becomes a generator, ▶
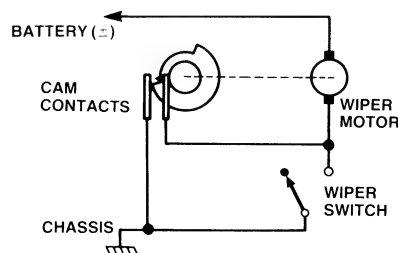

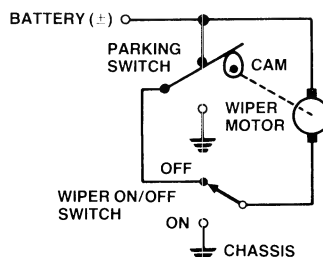**Figure 1.** Self-parking arrangement for a wound field wiper motor.

Figure 2. Self-parking arrangement for a permanent magnet wiper motor.

HOW IT WORKS — ETI-335

The best way to understand how this circuit works is to first look at the various circuit elements employed, then the step-by-step operation.

IC1 is a one-second monostable multivibrator that drives Q1. This operates the relay, RL1, the contacts of which operate the windscreen wiper motor.

IC1 is triggered via IC3d. Initially, pin 1 of this gate will be low (0 V), held down via R4 and R5. Pin 2 of IC3d will also be low initially. This is connected to the output of IC5 (pin 6) which will be at 0 V as its two inputs will initially be at 0 V.

IC2 has pins 2 (trigger) and 6 (threshold) tied together. Initially, they'll be low (below threshold), and the output (pin 3) will appear as an open circuit.

IC3a and IC3b form a flip-flop. This controls IC4, an astable multivibrator. The flip-flop inputs are pin 8 of IC3a and pin 13 of IC3b. Initially, both will be low and the flip-flop output will be low. Thus IC4 is disabled.

The output of IC4 drives the input of IC6, a dual binary counter with its two sections cascaded. Each counter has a 4-bit output. These outputs are connected to a resistor ladder network, making a 'stair step' generator. Thus, the voltage on pin 3 of IC5 rises in small 'steps' as IC4 oscillates, stopping on the last step when IC4 ceases to oscillate, providing a voltage 'memory'.

Now, let us see what happens when the WIPE button is pressed for the first time.

Operating PB1 puts a voltage pulse across R1. As C1 is discharged, this pulse appears across R4 and thus a logical high ('1') appears on pin 1 of IC3d. The output of IC3d (pin 3) will initially be high, going low (0 V) when pin 1 goes high. This triggers IC1 and its output, pin 3, goes high for a period of one second.

This turns Q1 on and the relay will be held operated for one second, causing the wiper motor to operate. The wiper will complete one wipe and, as it takes longer than one second, the relay will have dropped out by the time the wiper returns to the start position and the wiper motor will thus 'park'.

When Q1 turns on, its collector goes low and Q2 will be biased on via R15-R16. Thus, C7 will charge rapidly via R23. It can only charge to a maximum of 6.2 volts, limited by the zener diode ZD2.

After IC1 has completed its one second timing cycle and Q1 turns off, Q2 will turn off and C7 will discharge slowly via R9-R10, taking about 40 seconds. The voltage across R10 provides a small voltage which is applied to the 'control' pin (5) of IC2, which affects the threshold level at which IC2 can be triggered.
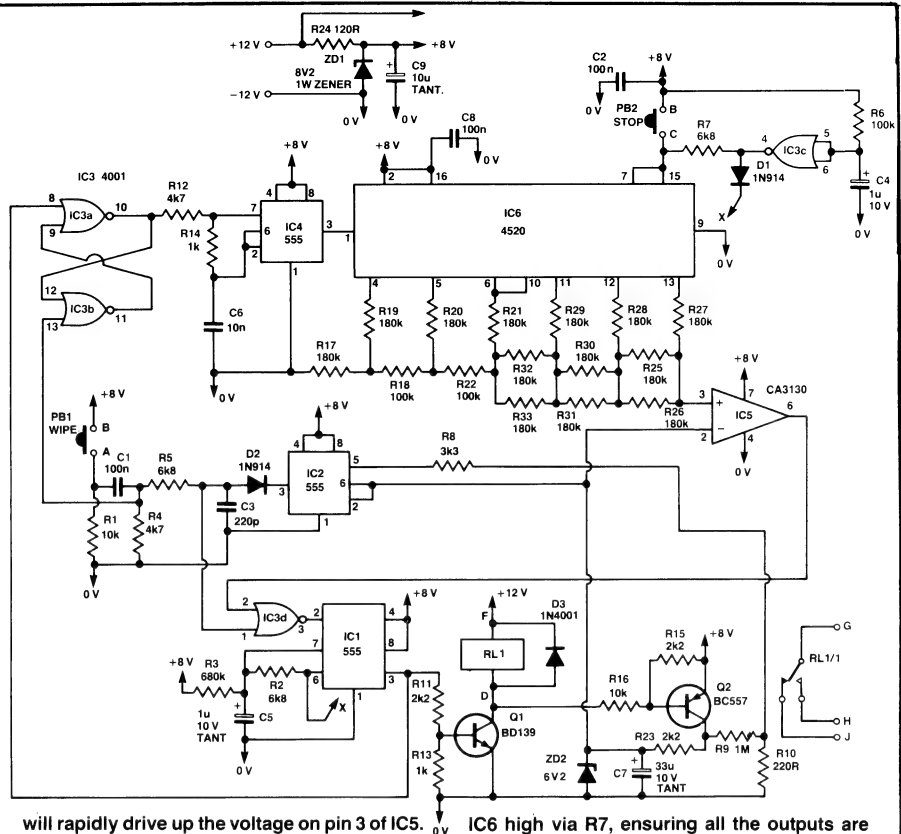
The flip-flop, IC3a-b, remains unchanged when PB1 is first pressed. Both flip-flop inputs (pins 8 and 13 of IC3) go high immediately PB1 is pressed, and thus the flip-flop output will remain low and IC4 will remain disabled.

When C7 is charged, while it remains sufficiently charged, IC2's trigger-threshold pins (2 and 6) will be above the threshold and pin 3 will pull the cathode of D2 low (almost to 0 V). At the same time, the inverting input of IC5 (pin 2) will be held at the same voltage as is on C7 and its output will be driven to 0 V.

If the WIPE button is pressed again within 40 seconds of the first press, a voltage pulse will appear across R1 and R4, as before, but this time pin 1 of IC3d is held low by the output (pin 3) of IC2, via D2. Thus, IC1 won't trigger via this means.

However, as pin 8 of IC3a (one flip-flop input) is held low via R11-R13, the voltage pulse across R4 will appear on the other input of the flip-flop, pin 13, changing its output (pin 10/12) from low to high. Thus, IC4 is enabled and will commence to oscillate.

As IC4 oscillates, the stair step generator will rapidly drive up the voltage on pin 3 of IC5. When it reaches the same voltage as that on pin 2, the output of IC5 will immediately go high (jump to +8 V), driving pin 2 of IC3d high. Pin 3 of IC3d will then go low, triggering IC1. Thus, Q1 operates the relay once again and the wiper wipes.

When IC1 triggers this time, pin 5 of IC3a will go high and the flip-flop output will go low, disabling IC4 and stopping the count in the 4520. The output voltage of the stair step generator will thus stop at that point — providing a 'memory' of the voltage left on C7 after it discharged for the period between the first and second presses of PB1.

When Q1 turns on again, Q2 will turn on again, charging C7, raising the voltage on pin 2 of IC5 above that on pin 3. This will now drive the output of IC5 to 0 V once more, setting pin 3 of IC3d high once again, restoring the initial conditions.

After IC1 completes its timing period, Q1 and Q2 will turn off and C7 will begin to discharge again. When the voltage on C7, and thus the voltage on pin 2 of IC5, drops to that held on pin 3 by the stair step generator, the output of IC5 will go high, triggering IC1 via IC3d, as before, and the whole cycle will repeat at that interval it takes for C7 to discharge to the voltage 'remembered' by the stair step generator.

You can shorten the interval at any time by pressing PB1 between wipes.

To stop the wipe sequence, press PB2. This puts a momentary high on the 'master reset' inputs of both counters in IC6 (pins 7 and 15). All outputs are then reset low. This drops the voltage on pin 3 of IC5 to 0 V, its output then going to 0 V, setting IC3d to the initial conditions.

IC3c provides a 'power-on reset'. This ensures that the controller does not operate the wipers when the ignition is turned on and power is applied to the unit. It works like this: Capacitor C4 will be initially discharged, holding the inputs of IC3c low. When power is applied to the unit, pin 4 of IC3c will immediately go high. This drives the master reset inputs of IC6 high via R7, ensuring all the outputs are low, and also drives the threshold input of IC1 (pin 6) high via D1, preventing IC1 from operating and holding its output (pin 3) low. Thus Q1 and RL1 cannot operate.

Capacitor C4 will slowly charge via R6 and when the voltage across it reaches the high threshold (about 4 V, ±1 V) of the IC3c inputs (pins 5, 6) the output, pin 4, will go low, readying IC6 for counting. Diode D1 will now be reverse biased and IC1 will be ready for operation.

That covers the general operation, but there are a few more details you'll need to know for better understanding of its operation.

Firstly, the period of IC1 is determined by R3 and C5. The actual period is not critical, so close tolerance components are not necessary here.

The frequency at which IC4 oscillates is determined by R12, R14 and C6. This is about 2 kHz. Here too, the exact frequency is not important, it simply means that at that rough frequency, the stair step generator output steps up to the required level very rapidly.

The RC network consisting of R1-C1-R4 is there simply to provide a pulse. When PB1 is pressed, C1 will initially be discharged, so the voltage across R4 will rise instantly to 8 V. But C1 will charge fairly rapidly and the voltage across R4 will die away quickly. The RC network of R5-C3 is an integrator which 'cleans up' the pulse from PB1. Contact bounce in PB1 may prevent reliable operation of IC3d and thus IC1.

Diode D3 shorts out the back-emf of the relay coil when Q1 turns off, protecting Q1 from collector-emitter reverse voltage breakdown.

The +8 V supply is provided by a simple zener regulator consisting of R24 and ZD1. Capacitor C9 provides supply rail bypassing, as do capacitors C8 and C2.

The 'memory' interval is determined by C7 and R9. We do not recommend you vary R9 if you want to vary the memory interval. Vary the value of C7 instead.

current through the short circuit sets up a field in the armature which reacts with the permanent magnet field so as to produce a force opposing the rotation of the armature.

Connection of the wiper controller relay contact to the wiper system differs for each scheme, and this is covered later in the article.

Construction

Assembly of the project is quite straight-forward. We recommend you use our pc board design. This avoids wiring errors and provides a robust mount for the parts. You can make your own pc board or buy one ready made (see the 'Shoparound' page in this issue). We'll assume you're using our pc board.

All the electronic parts are mounted on the board. The relay and two pushbuttons are mounted elsewhere, in convenient places in the vehicle. Tackle the pc board assembly first. Before commencing assembly, go over the board looking for broken tracks, small 'bridges' between tracks — particularly where they run close together and between IC pins. Also look for holes that haven't been drilled. If, or when, all is well you can tackle the assembly.

There are a total of 11 links on the board. We did this to avoid the expense of a double-sided pc board. Nine of the links are simply straight 'straps' using 22 gauge tinned copper wire (identified by dotted lines on the overlay). The other two are 'flying wire' links — one on the top side of the board (the black, snaky line on the overlay), the other underneath IC6 (shown in the accompanying photograph). Install the tinned copper wire links first. Note that one runs beneath IC5 and another beneath IC6. The flying wire links use insulated hookup wire and are installed later.

With the links in position, all the resistors can be soldered in place. The overlay has been laid out so that component placement is easily identified. Component numbers start in the top left hand corner of the board and go down, then across the board in increasing number. The last resistor (R33) is at the bottom right of the board.

Solder the capacitors in place next. Follow with the two 1N914 diodes, ZD1 (8V2), ZD2 (6V2), Q1 (BD139) and Q2 (BC557). The diodes and transistors have to be correctly oriented. Check which way round they go by looking at the component pinouts and the board overlay.

Now solder IC1, IC2, IC4 and IC5 in place. These are all in 8-pin packages. ICs 1, 2 and 4 are all 555s, while IC5 is a CA3130. Note that all ICs are oriented the same way, with pin 1 toward the 'top' of the board. Last of all, solder IC3 and IC6 in place. These are both CMOS ICs. Only handle them with your thumb and forefinger, holding the package by the ends so as to avoid touching the pins. If you're new to project assembly, a metal IC insertion tool is a great help. Solder pins 7 and 14 of IC3 first, then the other pins. With IC6, solder pins 9 and 16 first, then all the other pins. Do not use IC sockets as vibration in a vehicle can 'jog' the ICs out of the sockets.

Now you can install the flying wire links.

Connection between the board and the external components, the relay and pushbuttons, is made via a six-way terminal
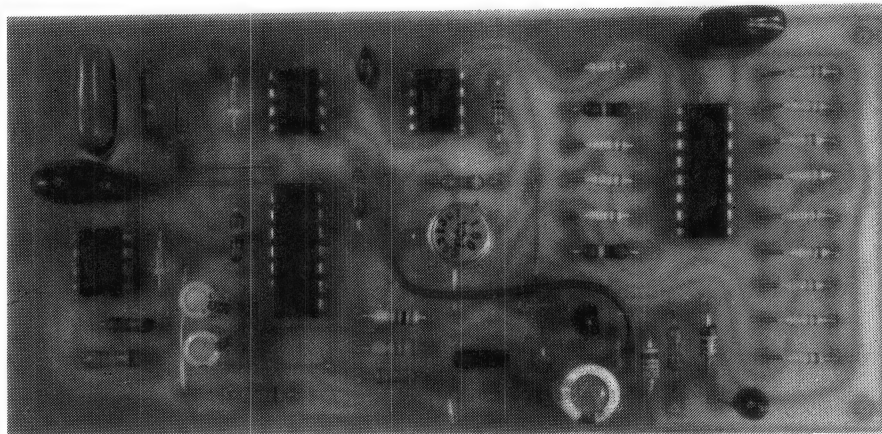
block. At this stage, you're going to have to work out where everything is to fit in your vehicle. You've probably already done that, anyway. You could temporarily hook things up and try it out (without connecting the relay contacts), just to see if it works and to sort out any possible troubles before finally installing the unit.

When testing it out, check that it works as described and see that the between-wipes 'memory' is at least 30 seconds. This will vary somewhat from unit to unit, because of the tolerance range of C7 and R9. That doesn't really matter, just so long as the maximum interval is about 30 seconds.
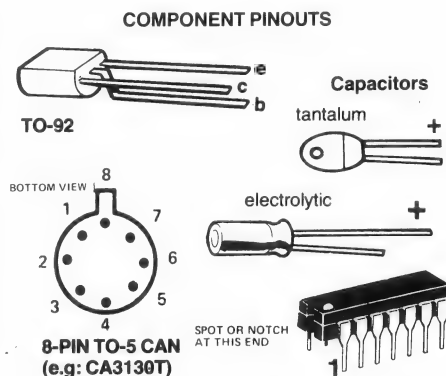
We mounted the pc board in a conveniently sized jiffy box and tucked it away under the dash. A 50 x 90 x 150 mm box will comfortably accommodate the board. Mount the six-way terminal block on the outside and inscribe the box with the A-B-C-etc terminal designations. The WIPE and STOP buttons can be mounted in any convenient position on the dash — either by drilling holes in the dash or mounting them to a box or bracket which is then affixed to the dash.

For the pushbuttons, you'll find the larger variety better to use, not the miniature ones. Both PB1 and PB2 are momentary-contact (SPST) types. Dick Smith Electronics stocks a suitable type, catalogue S-1199, as do Altronics (catalogue no. S 1080) and Electronic Agencies (catalogue no. SE0252). All these have a 15 mm square button (you can have any colour you like, so long as it's red) and require a 12 mm mounting hole.

The relay, as originally suggested by J.D.W., can be mounted in the engine compartment. This means you don't hear it going 'click-clock' all the time when the wipers are in use. Any standard 12 V relay with a set of changeover (SPDT) contacts rated at 5A at least can be used. If you can find one with lugs that take automotive-type slip-on spade connectors, so much the better.

Don't forget to wire D3 across the relay coil. You could, if you like, mount D3 on the six-way terminal block. (No, we didn't forget to include this on the board. It's just that, as the board was getting pretty cramped, it was more convenient to mount D3 off the board.)

Secure the relay firmly with a bracket. Use medium or heavy duty hookup wire (10 x 0.2 mm or 24 x 0.2 mm) to wire in the relay and pushbuttons.

Circuit board. The completed pc board. Note that some resistors are stood on end. The pc board pattern is reproduced on page 111.

COMPONENT PINOUTS

TO-92

Capacitors
tantalum

electrolytic

BOTTOM VIEW
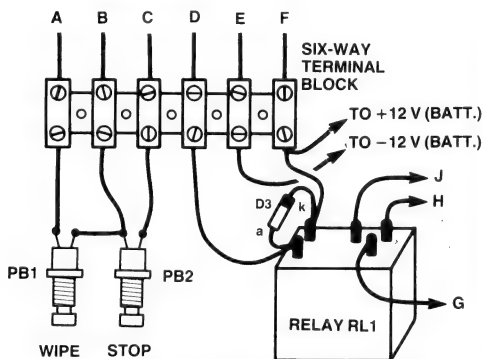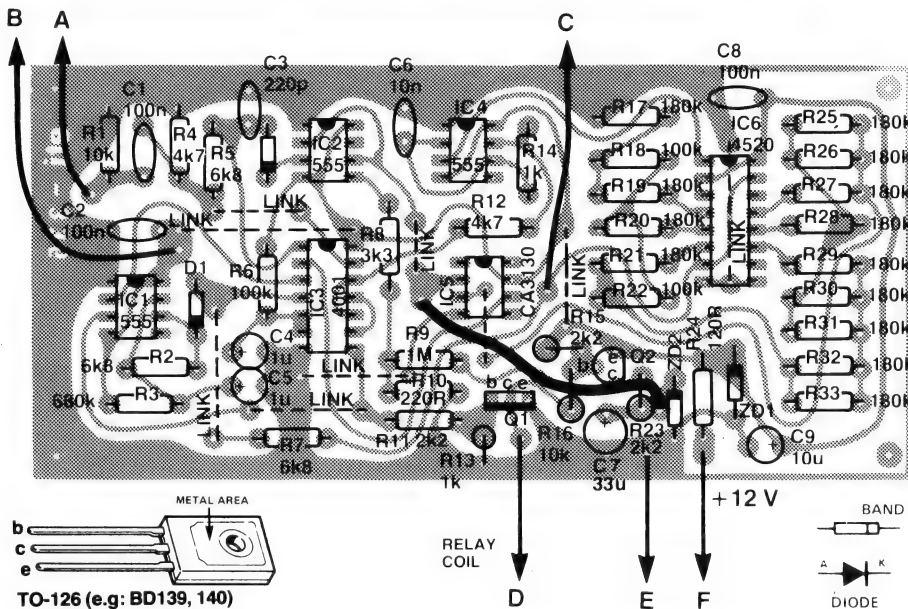
8-PIN TO-5 CAN (e.g: CA3130T)

SPOT OR NOTCH AT THIS END

Wiring it to the wiper system

The general wiring schematics for single- and dual-speed wiper systems employing wound-field motors are shown in Figures 3 and 4. In each case, the *normally open* relay contacts of the controller are wired in parallel with the parking switch. Trace the wiring between the wiper motor and the switch. For the type of system shown in Figure 3, the switch will have two wires running between it and the wiper motor. It should be an easy matter to sort out which wire is which and to connect the relay contacts accordingly.

The dual-speed system shown in Figure 4 will have three wires running from the wiper switch to the motor. Grounding lead 1 should set the wipers going in 'high speed', grounding leads 2 or 3 should set the wipers going in 'low speed'. You can connect the normally open relay contacts (G and H) from 2 or 3 to chassis, or from 1 to chassis. In the latter case, you can operate the wipers right up to maximum speed.
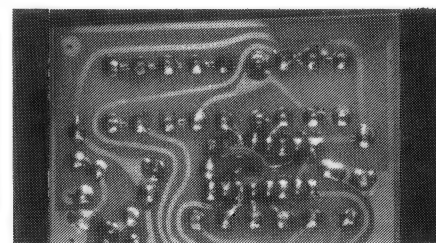
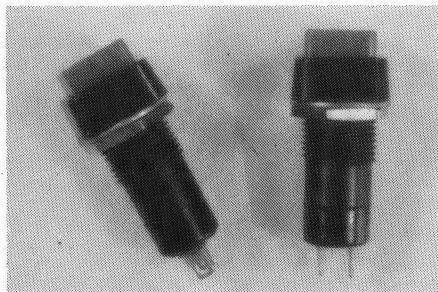**Underside link.** Rear view (copper side) of the board showing the link between pins 6 and 10 of IC6.

TO-126 (e.g: BD139, 140)

RELAY COIL

BAND

DIODE

+12 V

SIX-WAY TERMINAL BLOCK

TO +12 V (BATT.)
TO −12 V (BATT.)

PB1 — WIPE
PB2 — STOP

RELAY RL1

Wiring. The board is wired to the pushbutton, relay and supply via a terminal block. The +12 V goes via an ignition-switched fuse (−12 V for +ve earthed cars). The relay contacts connect to wiper system.

Buttons. The two pushbuttons we used. Miniature types are not recommended.

A dual-speed permanent magnet system is illustrated in Figure 5. Here, the wire from the wiper switch to the parking contacts (3) is cut at X-Y and the wiper controller's *normally closed* contacts (J and G) connected across the cut. The normally open contact (H) is connected to chassis. If you need maximum wiper speed when using this system, simply use the wiper switch as you normally would.

In most instances, the chassis (earth) contact for the wiper switch is made through the body of the switch. Those systems which include a washer system where the washer is activated by pushing the wiper switch will have an extra wire for the washer. Some systems, usually found on British cars, are arranged to operate independantly of an earth (i.e: do not use the vehicle chassis as a

return lead) so that they may be fitted to either positive or negative earthed electrical systems. In such cases, you'll find a fifth wire extended from the wiper switch to the wiper motor, as indicated in Figure 5.
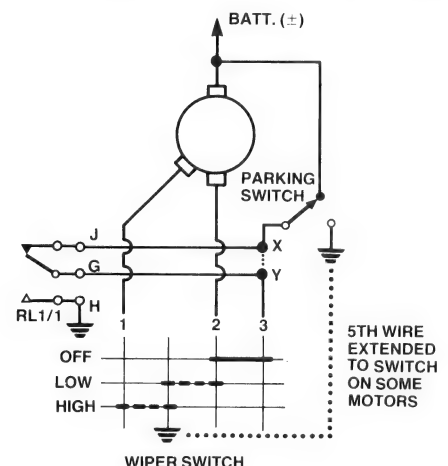
The installation of this wiper controller in no way alters normal operation of the wipers via the wiper switch installed in the vehicle. ●
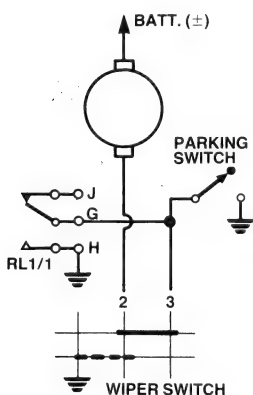
Figure 3. Wiring the relay contacts to a single-speed wound field wiper system.
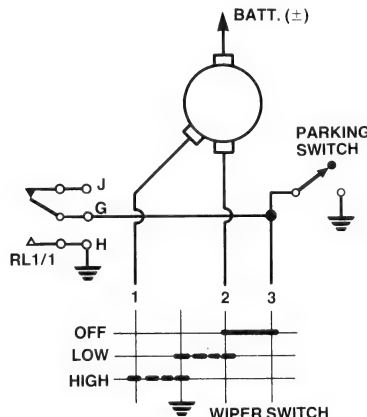
Figure 4. Wiring the relay contacts to a dual-speed wound field wiper system.

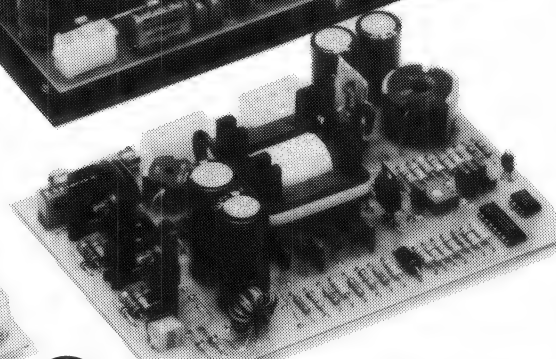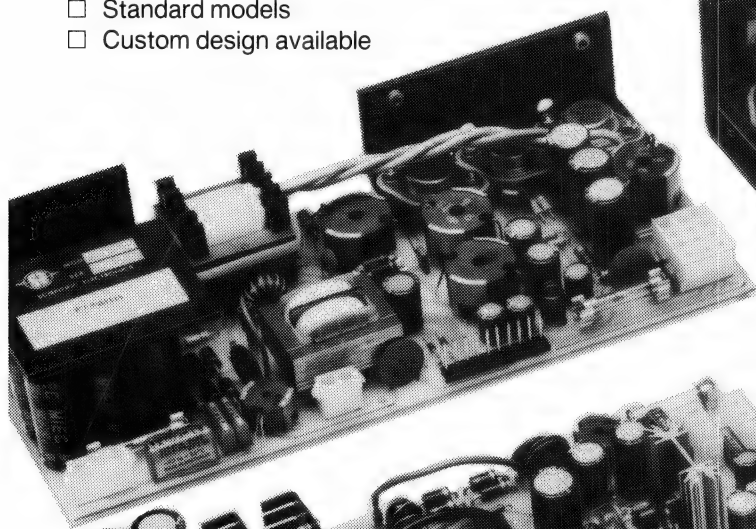**Figure 5.** Wiring the relay contacts to a dual-speed permanent magnet wiper system.