R/C MODELER

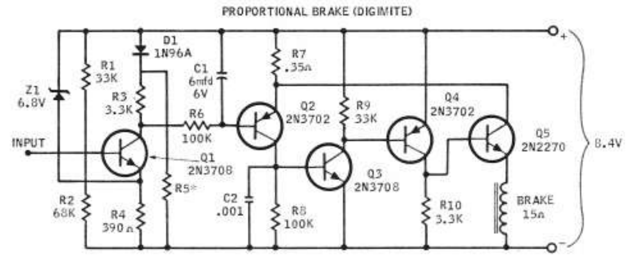
TECHNICAL FEATURE

THIS brake control unit was designed to obtain proportional and linear braking action from the new electric brakes which have recently been introduced. It was designed by Charles Call of the Austin R/C Association with PC board design and Digimite flight tests by Hank Walker. Al Jekel provided the testing for the Orbit 7-14.

The control is obtained from an auxiliary channel of a digital proportional transmitter. When constructed on the printed circuit board shown, the unit fits in a plastic box measuring 1" x 1" x ¾". By using Tantalum electrolytic capacitors, which are smaller but more expensive, the unit fits a box 1" x 1" x ⅝". Total cost of the electronic parts is $6.45 for the Bonner Digimite and $5.95 for the Orbit 7-14. In addition to providing brake control, this unit may also be used to control other devices, even though proportional control is not necessary. The elimination of one resistor (R7) gives non-linear action to permit the device to function as an on-off switch. Due to its low cost and simplicity, it provides an ideal method for obtaining control for lights, bomb and parachute dropping mechanisms, and other similar devices from an auxiliary channel.

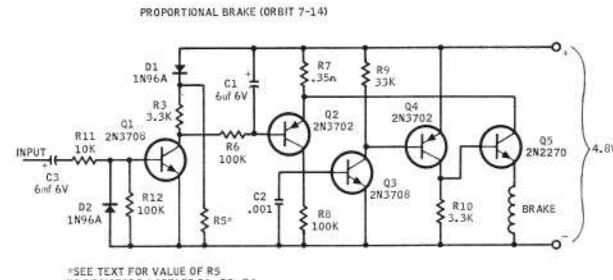
PROPORTIONAL BRAKE CONTROL

BY COL. HANK WALKER



*SEE TEXT FOR VALUE OF R5

FIGURE 1



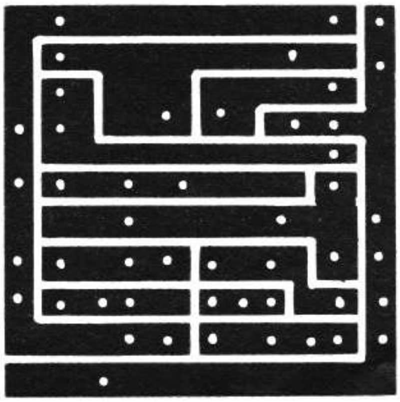
*SEE TEXT FOR VALUE OF R5
NO RESISTORS LABELED R1, R2, R4

FIGURE 2

The control unit draws only 2-3 milliamperes at idle. It uses the receiver power supply, precluding the requirement for additional batteries. The added drain during normal operation is so small that it does not appreciably reduce the receiver "switch-on" time. The most obvious advantage of this brake control over using a micro-switch actuated by a servo is that the brake is not turned on in flight during maneuvers requiring use of that servo, hence no unnecessary brake current is drawn. In addition, the control is proportional and the voltage applied to the brake is linear, as opposed to the full-on or full-off control obtained with the conventional switching arrangement. It does not interact with other functions and may be used simultaneously with all other controls. The unit is simple and straightforward, using inexpensive components available from a single source. It has no critical adjustments and is temperature stable to above 130 degrees F. It can be used to power a single brake or two brakes simultaneously. It is "fail-safe" in that, when the transmitter is off, the brakes are automatically released, so no unnecessary current is drawn.

Although most of the testing has been done with the WAG electric brake and a Bonner Digimite system, the control has also been modified for the Orbit 7-14 and proved equally successful. It has been used with the Digimite to control a single brake and to control two brakes in series with no modifications to the circuit. It is capable of varying the voltage from 0 to 7 volts in either configuration. It has completed several hundred flights with no trouble whatever. Similarly, with the Orbit, which has only 4.8 volts available, the unit has been used in both the single and two-brake configuration. With a single brake control, 0 to 4 volts is available and with two brakes, 0 to 3.7 volts per brake is available. With the Orbit system it may be necessary to reduce the value of resistor R7 when using two brakes in parallel in order to obtain maximum braking voltage. (See Operation and Adjustment). Testing with the Orbit has been limited, but no difficulties have been encountered.

Twice actual size printed circuit board for Bonner Digimite proportional brake.



In addition to the tests mentioned above, the unit has been used to power a small electric motor for a bomb drop mechanism and, similarly, has been used to control lights for night flying.

Since, at the time of this writing, no other electric brakes were available, the tests have been restricted to the Ace WAG units. However, the control can handle any load with a DC resistance of 15 ohms or higher on the Bonner, and any load with a DC resistance of 7 ohms or higher on the Orbit 7-14. Lower DC resistance loads can be handled if a suitable dropping resistor is used in series.

The basic circuit is adaptable to other digital proportional units on the market by making appropriate changes in the input circuit. No other such units were available for testing, however.

Theory Of Operation

The following applies specifically to the Digimite. The principle of operation for the Orbit unit is similar. There is a difference in the signal supplied by the receiver in these two units, necessitating a different input circuit. The remainder of the amplifier is the same for both units. In addition, the Digimite uses an 8.4 volt power supply while the Orbit uses 4.8 volts. All voltage references and formulae apply to the Digimite.

The brake control circuit is basically a stabilized DC amplifier. (See Fig. 1 and 2.) Q1 amplifies and inverts the incoming pulse signal from the receiver. The output of Q1 is then coupled through R6 to the base of Q2 which is the first stage of a four stage direct coupled DC amplifier consisting of Q2 through Q5. The capacitor C1, across the plus 8.4 volt supply and the base of Q2, is a pulse width averaging, or integrating, capacitor. The average (or DC) voltage from the output of Q1 appears across C1 and is amplified to provide brake drive voltage.

The output from the receiver serves to clamp the base of Q1 such that this transistor is turned off during the frame rate except when the auxiliary channel pulse is present to operate the brake. While Q1 is turned off, its collector voltage is equal to the supply voltage minus the forward voltage drop across D1 (approximately 8.0 volts). During the auxiliary pulse, the base is released and Q1 turns on for 1.1 MS to 2.3 MS, depending on the position of the transmitter control. The collector of Q1 is released by the receiver control circuitry. The lower voltage swing is maintained constant and independent of the supply voltage due to the action of the Zener diode Z1. The DC voltage which appears across C1 is dependent upon the pulse width as given by the following formula:

$$V_{C1} = \frac{\text{Pulse width (ms)} \times 6.7 \text{ volts}}{\text{Frame width (ms)}}$$

For a pulse width of 1.1 ms:

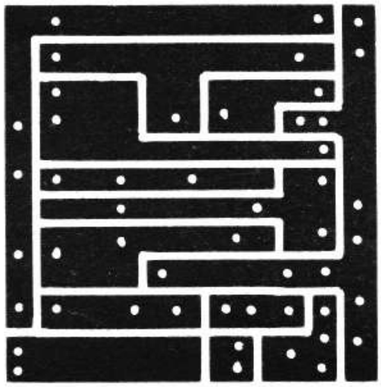
$$V_{C1} = \frac{1.1 \times 6.7}{35} = 210 \text{ mv.}$$

For a pulse width of 2.3 ms:

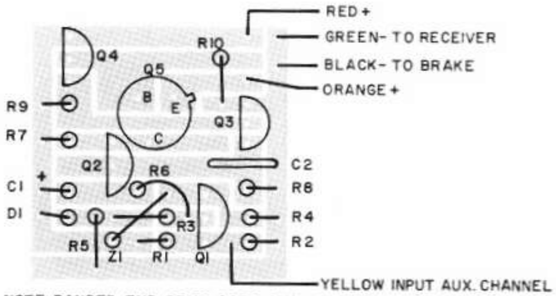
$$V_{C1} = \frac{2.3 \times 6.7}{35} = 440 \text{ mv.}$$

Thus, the total DC signal input to

Twice actual size printed circuit board for Orbit 7-14 proportional brake.



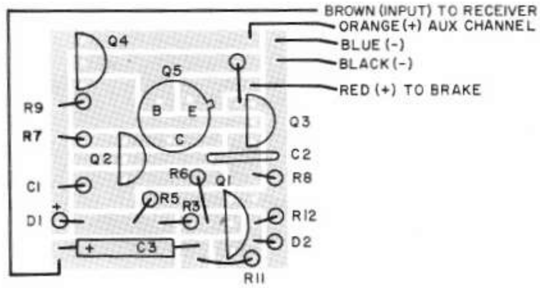
PROPORTIONAL BRAKE (DIGIMITE)
PRINTED CIRCUIT BOARD AND COMPONENT LOCATION



NOTE: BANDED END OF D1 GOES AWAY FROM POSITIVE STRIP
BANDED END OF Z1 GOES TOWARD POSITIVE STRIP

FIGURE 3

PROPORTIONAL BRAKE (ORBIT 7-14)
PRINTED CIRCUIT BOARD AND COMPONENT LOCATION

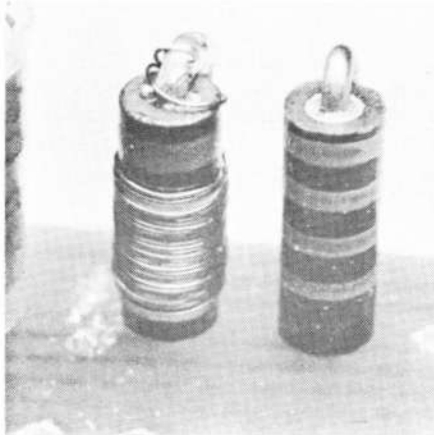


NOTE: BANDED END OF D1 GOES AWAY FROM POSITIVE STRIP
BANDED END OF D2 GOES AWAY FROM NEGATIVE STRIP
THERE ARE NO RESISTORS LABELED R1, R2 OR R4.

FIGURE 4

BOTTOM VIEW

FIGURE 5



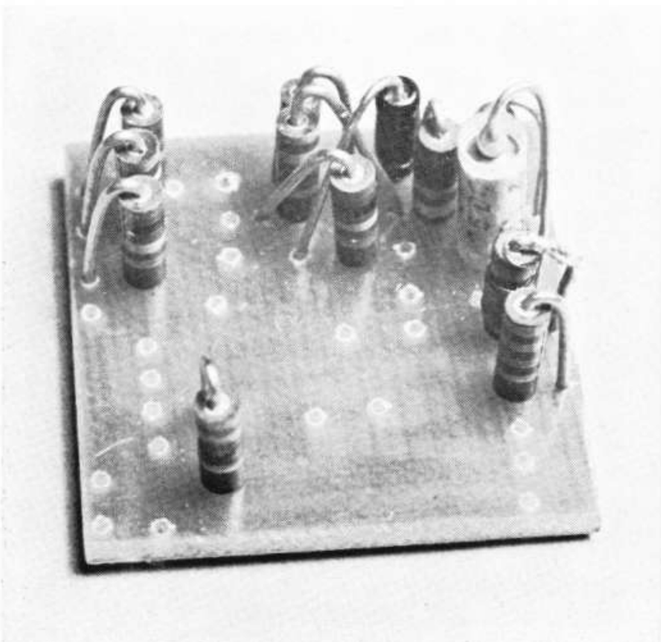
Close up of winding on R7.

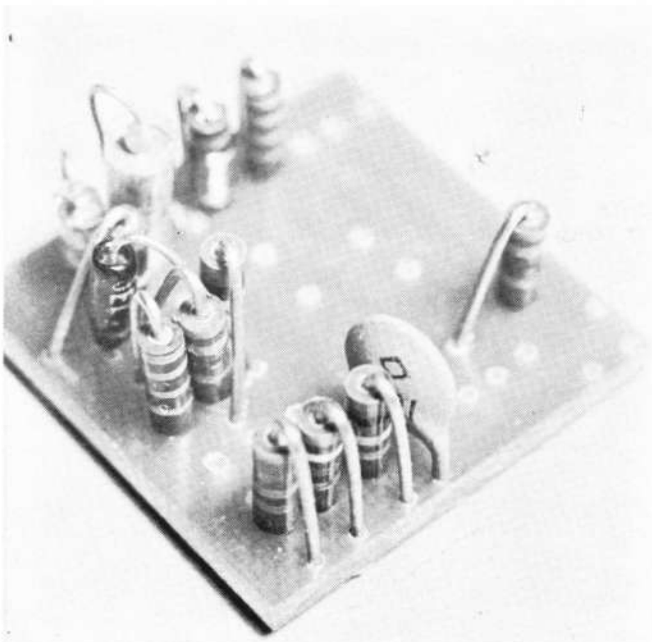
Q2's base varies from 210 mv at full off to 440 mv at full on.

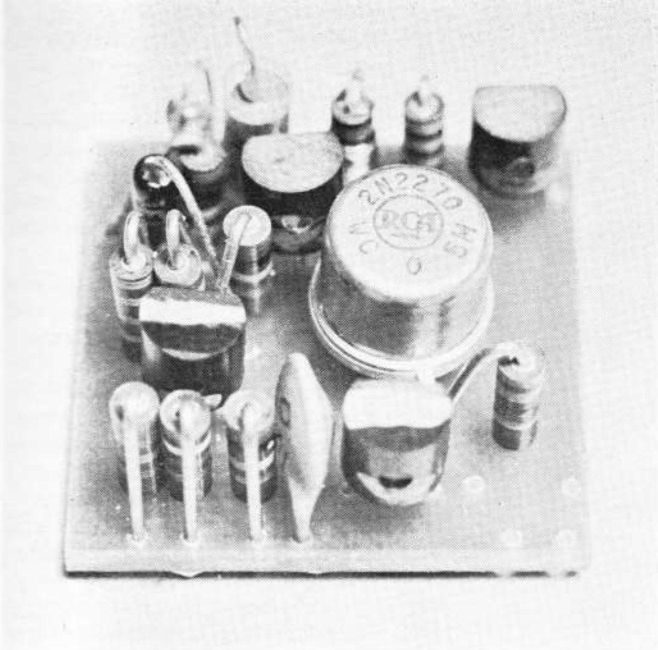
The signal voltage is then amplified by Q2, Q3, Q4, and Q5 to provide a 0 to 7 volt output voltage which is applied to the brake. The amplifier gain is made linear and stable by negative voltage feedback across resistor R7.

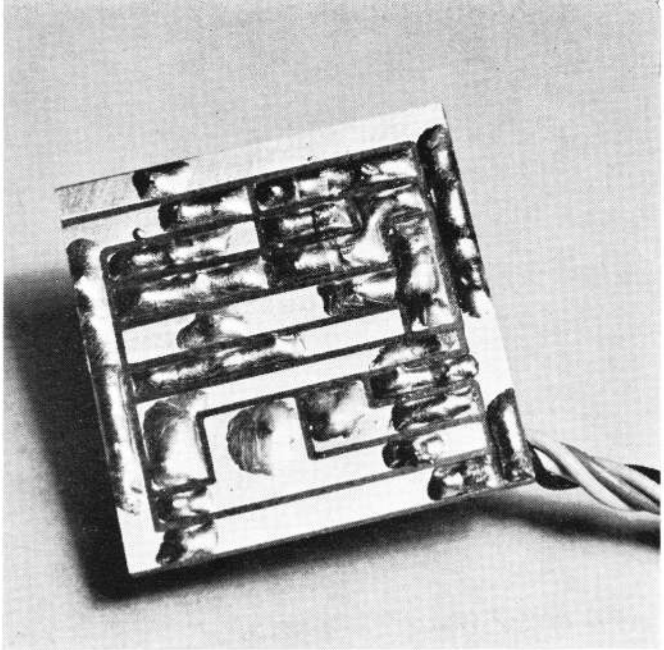
Construction

The prototypes were photo-etched on glass-epoxy printed circuit board. The full scale printed circuit layout is shown in Figure 3 for the Digimite and Figure 4 for the Orbit. The board is small, but the lands are wide enough so that the soldering job is not too tedious. A superior method of preparing the printed circuit board is to trace the diagram directly onto a small piece of window glass with India ink. This glass is used as a negative (ink side toward board) to expose photo-sensitive board. Be sure to include the dots for component location to make centerpunching the copper unnecessary. This method of board preparation was suggested by Al Jekel, and the procedure results in a quick,









simple, and professional piece of work. Other methods of preparing the board may be used. Of course, the printed circuit board may be scaled up to any size desired if the builder does not require the unit to be the small size shown. A #67 drill is preferable for drilling the holes for component mounting, but a #60 may be used. When mounting the components on the board, install the transistors last. This will prevent possible damage from repeated applications of heat during soldering and will also permit slight shifting of their position in order that all components fit. Do not install resistor R5 until the procedure outlined under Operation and Adjustment is completed. Observe polarities of the diodes and electrolytic capacitors. These are indicated in Figures 3 and 4. When constructing the Digimite board install Zener diode Z1 before mounting resistor R3. The lead of Z1 should pass under the lead of R3. All diodes are glass encased and somewhat fragile. Use care to prevent breakage while installing them. All the small transistors are mounted with the flat side to the left when the board is viewed as in Figures 3 and 4 (Emitter toward top). See Figure 5 for transistor lead identification. Figures 3 and 4 indicate the location of the leads for Q5.

Use a small soldering iron with a pointed or small chisel tip and apply heat only long enough to obtain a good bond and drive the flux from the solder. Remove the iron by rapidly sliding it up the lead of the component being soldered. A proper solder joint should be shiny and should completely surround the lead of the component.

After all components except R5 are installed, recheck for wiring errors. Then clean the bottom of the board with

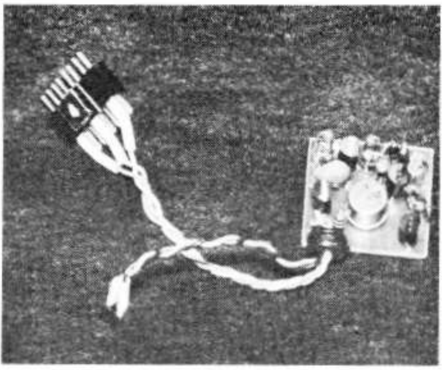
(Continued on page 66)

PARTS LIST

Ref. Designator	Description	Manuf. & Part No.
*R1	33K	
*R2	68K	
R3	3.3K	
*R4	390 Ohms	
R5	See instructions	
R6	100K	
R7	See below	
R8	100K	
R9	33K	
R10	3.3K	
**R11	10K	
**R12	100K	
(All resistors are carbon ¼ watt, 10%)		
C1	6 Mfd. 6V	
C2	.001 Mfd. 1000V	Sprague 5HK-D10
**C3	6 Mfd. 6V	Sprague TE 1085
D1	Germanium Diode 1N96A	
**D2	Germanium Diode 1N96A	
*Z1	Zener Diode, Silicon 6.8V 1N957A	International Rectifier
Q1	2N3708	Texas Instruments
Q2	2N3702	" "
Q3	2N3708	" "
Q4	2N3702	" "
Q5	2N2270	RCA
	Plastic Box	Ace R/C #21K1 PB#1A

R7 Wind 9 inches of #38 copper wire around a ¼ watt resistor with a value of 10 ohms or more. Solder the wire to the resistor leads at each end. Do not use a large size of copper wire with more turns as this may induce instability into the circuit.

** Indicates part is for Orbit 7-14 only
* Indicates part is for Bonner Digimite only



PROPORTIONAL BRAKE

(*Continued from Page 35*)

a suitable solvent to remove the flux. Place the input and output leads where indicated and proceed with adjustment.

Operation And Adjustment

These notes apply to the Digimite. See last paragraph of this section for Orbit adjustment. Transmitter and receiver batteries should be fully charged before making adjustments.

Connect the brake control to the receiver and brake. Install a voltmeter across brake winding. Avoid short circuits as this will result in failure of transistor Q5 as soon as the brake is actuated. In place of resistor R5 temporarily install either a resistor substitution box set at 47K, or a 100K variable resistor set at approximately 47K, or temporarily install a 47K resistor. With the receiver turned on, transmitter off, and the brake in the circuit, there should be no voltage across the brake. Set the brake control "off" (this is with the control knob rotated toward the top of the transmitter), and turn the transmitter on. There should still be no voltage across the brake. If the brake comes on partially when the transmitter is turned on, raise the value of R5 until there is no voltage. R5 is for the purpose of adjusting the "turn on" point of the brake. Decreasing R5 tends to turn the brake on sooner, while increasing R5 requires more control knob rotation to turn the brake on. This resistor is not critical and may vary from as low as 2.2K to as high as 470K. Do not lower R5 below 2.2K as this will tend to draw excessive current through CR1. If the circuit will not come on properly at a value between 2.2K and 470K for R5, check for wiring errors or a defective component. The nominal value for R5 is about 47K. The proper value of R5 will allow the brake to begin to turn on with about 10% or more of control knob rotation. Once the proper value for R5 has been determined, install a resistor of that value permanently.

The value of resistor R7 determines the amount of control knob rotation required to obtain a given voltage on the brake. In addition, it provides linearity. The value indicated will probably be correct for most applications. If the brake voltage does not reach 7 volts with the control at maximum setting, lower the value of R7 slightly by removing a few turns of wire. Conversely, if the brake voltage reaches maximum too soon, increase the value of R7 slightly by adding a few turns. If maximum voltage of lower than 7 volts is desired, increase R7 until the desired maximum voltage is reached when the control is at maximum setting. To use the control as a switch, such as for actuating a bomb drop mechanism, shorting R7 out will result in a more positive switching action. Note that changing the value of R7 does not change the "turn on" point established by R5.

Some instability may occur during testing if test wires are too long or if the transmitter signal is too strong. It may be necessary to provide RF decoupling of the test equipment and watch lead dress and/or remove the transmitter antenna when making the above adjustments. Once the unit is installed in the airplane, it is stable with the transmitter antenna installed and held only a few inches from the receiver antenna.

For adjustment of the Orbit, the same procedures are followed except that the nominal value for R5 is 3.9K and may vary between 2.2K and 68K. In addition, the maximum voltage obtainable from the Orbit is about 4 volts. The off position of the transmitter control will depend on which channel is being used to control the brake.

Installation

Once the adjustments outlined above have been carried out, no further adjustments should ever be necessary. Clean the printed circuit board and spray with clear Krylon or paint with clear dope to prevent high resistance shorts from developing and to protect the copper from tarnishing. Insert input and output leads through a rubber grommet (a servo mounting grommet is ideal) and install suitable plugs and sockets, keeping leads reasonably short. Mount the control in the plastic box, making a half moon cutout in both the bottom and the lid to accept the grommet. Foam rubber or polyurethane padding should be used in the box to prevent the control from rattling about. The completed unit can be placed in any convenient place in the airplane, but, as with other electronic devices, it should be surrounded on all sides by foam rubber or other suitable padding for maximum protection from vibration.

Please feel free to write me through RCM if you have any questions.