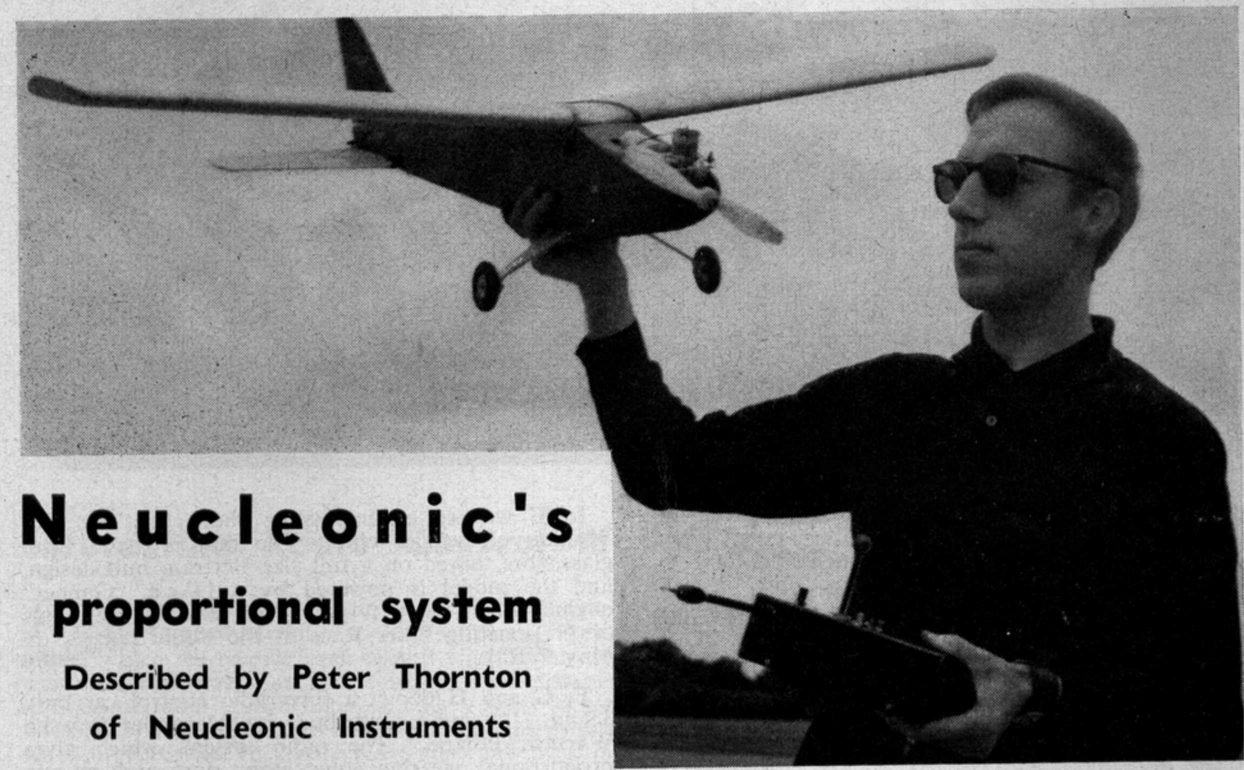


Neucleonic's proportional system

Described by Peter Thornton
of Neucleonic Instruments

THIS is a lightweight, all transistor, triple simultaneous proportional control system, offering full proportional control of rudder (or ailerons if desired) and elevator with progressive engine control.

All functions are independent of each other and are controllable simultaneously. Additional trim control is provided on both the Yaw and Pitch axis.

The equipment is mainly designed for the intermediate contest model, pylon racer, scale model, and of course the fly for pleasure model.

In all cases the system offers a near approach to full size flying techniques, as the transmitter control stick simulates almost exactly the control column of a full size aircraft.

Fundamentally, it is a variable pulse width, and rate, plus audio deviation system.

At the receiver end, three appropriate decoder circuits extract the required information from these three variables and pass it on in the form of a D.C. reference voltage to each of the two closed loop proportional servos and as switching signals to the progressive engine control servo.

Reference to the block diagrams will make this clearer.

Pulses are generated in the ramp function generator at a rate set by the elevator control potentiometer. These are continuously variable between 25-60 c.p.s. These pulses pass to a bistable trigger circuit, the output of which, consists of a pulse whose width is determined by the trigger level, which is set by the rudder control potentiometer. The pulse width employed in the system is continuously variable between 4:1 and 1:4 mark/space ratio.

This method of generating variable width and rate pulses is employed because of the freedom from interaction between width and rate which it affords.

After amplification and limiting, the output appears as a train of constant amplitude square wave pulse of variable width and rate. The high stability audio tone generator oscillates at a centre frequency of 1,100 c.p.s. and is swung to 1,400 c.p.s. and 900 c.p.s. for fast and slow engine control.

Two gating circuits couple the pulser output stage and the audio tone generator to the modulator. These gates perform two extremely important functions. First they allow the audio tone to appear only in the mark cycle of the pulse and second they isolate the outputs of the pulser and the tone generator from each other.

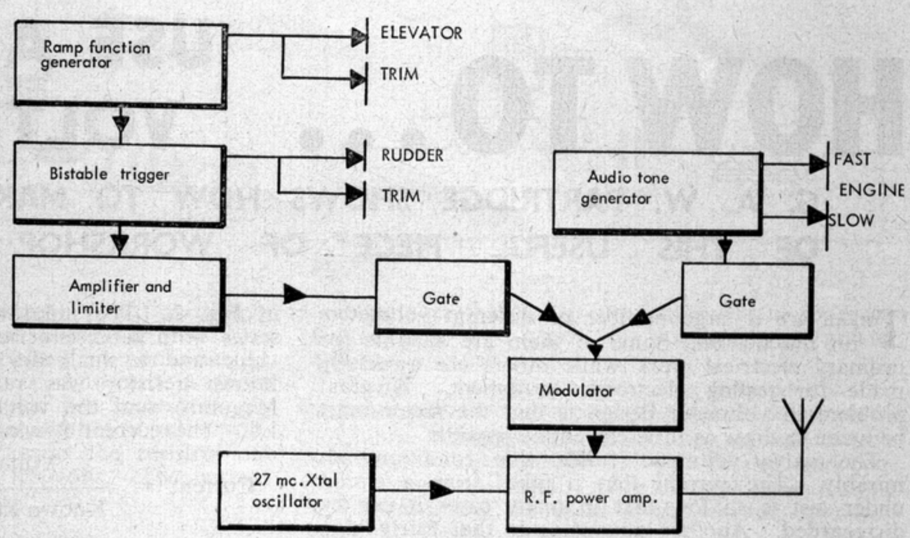
This is important because any pulses breaking through and appearing in the audio tone generator would tend to lock the tone frequency to some harmonic of the pulser, making accurate tuning of the tones impossible.

Temperature and voltage stabilisation is employed to ensure freedom from drift in these circuits and in practice it has proved to be completely drift free over a very wide range of temperatures. A stable crystal controlled 27 Mc/s oscillator drives the high output R.F. power amplifier to deliver maximum power into the aerial load and provides a range of 1,000 yards plus.

At the receiver the signal from the aerial is detected by a fairly conventional 27 Mc/s super-regen detector stage, though the quench frequency used is higher than normal practice, to avoid spurious interaction with the higher tone frequencies. After amplification the signal is split up at the emitter follower stage.

The 1,400 and 900 c.p.s. tones are selected by ferroxcube filters and after detection and filtering are used to switch the engine servo amplifier. The pulse envelope is applied to the mark/space detector, and then integrated and filtered to produce a D.C. reference voltage which is fed into the closed loop

Left: Peter Thornton with one of the Neucleonic Proportional outfits installed in a Veron Robot. The article describes the slight modifications necessary for this combination. Right: Transmitter block diagram.



proportional rudder servo.

As the reference voltage is proportional to the mark/space ratio, which is itself determined by the stick position at the transmitter, it is apparent that as the proportional servo follows this reference voltage it therefore follows exactly, the stick position at the transmitter.

The pulser at the emitter follower stage is also fed to a trigger stage which is not affected by the mark/space ratio, but converts the pulse into a short duration spike which is used to trigger the monostable multivibrator.

This multivibrator gives out a pulse of fixed duration for every trigger pulse received.

These pulses are integrated and filtered to provide a D.C. reference voltage which is proportional to rate. This is fed to the elevator proportional servo.

Power requirements for the system are: Transmitter, 12 v. obtained from two 6 v. P.P.I. type dry batteries. Receiver and servopack, one 7.2 v. centre tapped DEAC pack.

Only one switch is required to switch the power to the receiver and servopack. This is a double pole switch which breaks the negative and positive leads to the DEACs, the lead to the centre tap is not switched. If a replacement switch is ever fitted it is essential that a similar double pole switch is used. A single pole switch in one lead must not be used.

General

The complete transmitter is housed in a dark blue enamelled and polished steel case with lettering in white.

The control stick pivots in a universal ball socket, allowing complete freedom of movement in all directions, and also excluding dirt and moisture from the electronics. Built in 'feel' by means of springing is incorporated on both main axis.

Engine control is provided by press button switches to the left of the control stick. To the right of the stick is the Pitch trim control and below the stick is the Yaw trim control. Size 7½ in. x 5½ in. x 2½ in.

The receiver case is dark blue enamelled duraluminium. One multi strand lead from the receiver terminates in a multi contact edge connector which plugs into the servo board. A second lead is the power lead which connects to the 7.2 v. DEAC pack via the on/off switch. Size 3 in. x 1¾ in. x ⅞ in. Weight 2½ oz.

The servos come ready mounted in pack form on a spring anti-vibration board. Four screws hold the complete assembly in the aircraft. At the rear of the board are the two proportional closed loop servos for rudder and elevators, each with its built in proportional amplifier. At the forward end of the board is the engine servo and alongside this is

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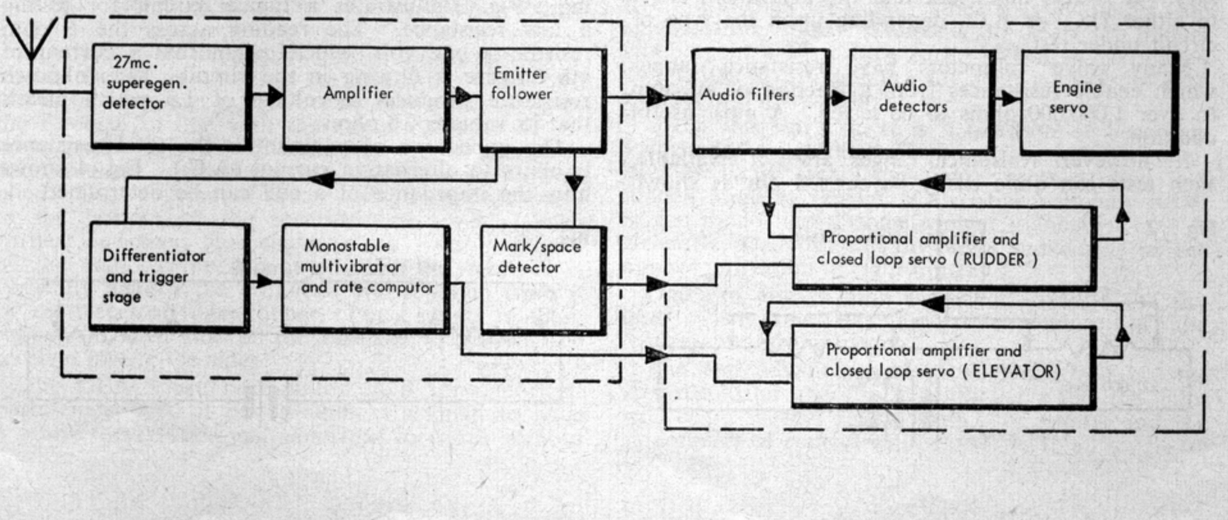
Below: Receiver Block Diagram.



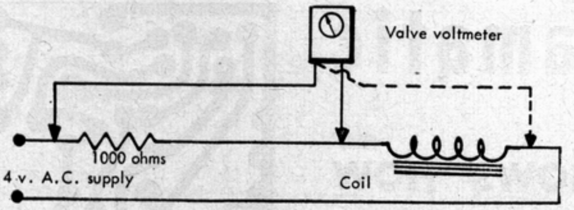


Fig. 4

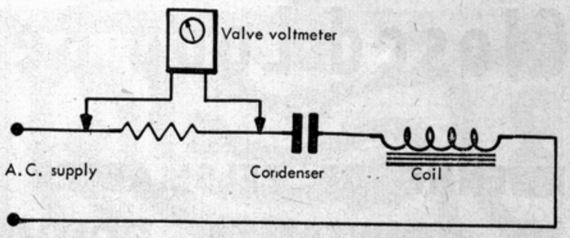


Fig. 5

Its resistance to direct current (D.C.) is simply measured in the same way as any other resistance. This is found to be say, 500 ohms. A non-inductive resistor of say, 1,000 ohms, is connected in series with it and also to a 50 cycle per second supply between 3 and 6 volts. Now, with the valve voltmeter measure the voltage across the resistor and let us assume that it reads 1.5 volts. The current in the circuit will therefore be:

$$\text{Current} = \frac{\text{Voltage across resistor}}{\text{Value of resistor}}$$

$$= \frac{1.5}{1,000}$$

$$= .0015 \text{ ampere}$$

The same current will be flowing through the coil so its impedance will be the voltage across it divided by the current. On testing, the voltage is found to be 1.6.

$$\text{Impedance} = \frac{\text{Voltage across coil}}{\text{Current}}$$

$$= \frac{1.6}{.0015}$$

$$= 1,067 \text{ ohms (approximately).}$$

Remember that this is the impedance at 50 cycles per second. The higher the frequency the greater will be the impedance.

Finally, a very simple test. Fig. 5 shows a circuit with an unknown current. How is it determined? Choose a resistor that is just high enough to give a voltage reading on the valve voltmeter, and connect it into the circuit. For example, the reading is 1.7 volts, and the value of the resistor, 50 ohms.

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

$$= \frac{1.7 \text{ volts}}{50 \text{ ohms}}$$

$$= .034 \text{ ampere}$$

or 34 milliamperes.

Provided the resistor is of a low value in comparison to the rest of the circuit, negligible error will result.

There are other useful tests such as inductance, power factor, and capacitance measurements, but they are a little beyond the scope of this article. However, sufficient has been said to show what a useful instrument the valve voltmeter is to the experimenter.

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a small blue case housing the engine discriminator circuits. Size 6 in. x 2⅜ in. x 2 in. high. Weight 7 oz.

Installation is simplicity itself. For example, a Veron Robot is modified as follows. Glue two pieces of ½ in. sq. engine bearer across the floor of the fuselage in line with the mounting holes of the servo pack. Use P.V.C. adhesive. Screw the servo pack to these anchoring points using the screws supplied. Glue four small squares of ½ in. foam rubber to the bottom of the receiver case, one at each corner, and then glue these to the front bulkhead of the radio compartment so that the receiver is vertically against the bulkhead and separate from it by the pieces of foam rubber. Put a square of foam rubber on each side of the fuselage to prevent the receiver hitting the sides.

The DEACs are best placed in a forward compartment so that if one is unlucky enough to have a prang the DEACs will shoot out forwards without crushing the other radio items.

As for flying proportional models, they are a lot easier to handle than some people would have us believe, but do start off with a fairly stable model first. Set the trim as near right as is possible before flying and then let it go. Once it is in the air, use small gentle stick movements to keep the model climbing in a very wide turn. When it has gained about 300 ft. altitude use the trim controls to give straight and level flight.

From this stage on it is a question of becoming accustomed to the feel of proportional, but remember, use only small stick movements at first. A sudden large movement of the stick will only result in the model doing some violent manoeuvre and it generally needs an equally large movement in the opposite direction to right things.

One can always fling the model around the sky later when one has gained experience of the equipment and the model.

The real advantages of proportional will become apparent after the first few flights when the pilot will begin to feel really "with" the model and the smoothness of control will be obvious to all.