MODEL CONTROL

PART ONE

The short series in PRACTICAL ELECTRONICS on Miniature Model Control gave constructional details of a transmitter, receiver, and three amplifiers designed specifically for use in small models.

Sufficient information was given to allow the reader to construct and put into operation the basic units of equipment, to the point where a single or multiple on-off function could be obtained in response to a push-button command from the transmitter.

The next stage described here is conversion of a switched function to mechanical operation of various controls within the model itself.

AN IDEAL form of model control system is one where angular rotation of potentiometer spindles at the transmitter is faithfully reproduced by a like rotation of corresponding powered shafts in the model, which are linked to functions such as steering, or engine speed. The majority of existing systems only approximate to this ideal, for the very good reason that a "full house" proportional outfit is rather expensive, and may use as many as 60 or 70 transistors. Nevertheless, it is surprising what can be done with very simple equipment and a skilful operator, particularly in the field of miniature models.

STEERING

The ability to point the model in any desired direction can be claimed as the prime requirement, and it is possible to achieve interesting results with steering alone. Other controls, such as stopping and reversing, can be added later.

Before going on to a description of an integrated steering unit it would be as well to explain first the action of the clockwork escapement. The illustration of Fig. 1 may help to make clear the sequence of events, which is common to all four-arm escapements, including rubber powered ones.

Referring to Fig. 1, when a pulse is applied to the electromagnet by brief closure of the reed switch in the amplifier module, the latch will move down, releasing arm 1 of the rotor. The rotor is then free to move quickly under power, and drive the crank round, but the top of the latch has moved inwards and blocks the path of approaching arm 3, now on its downward journey. Thus, the rotor stops just before the crank has reached its full control position.

When the pulse ceases the latch is pulled back by its spring against the top stop, releasing arm 3. The bottom of the latch just has time to move in and stop arm 4 when arm 3 is released, and the crank attains full control position.

Therefore, with a single input pulse of indeterminate length, the escapement has unlatched, moved under power to the next position, and relatched on cessation of pulse, ready for the next command to be given. From this it will be clear that a four-arm escapement can provide positive positioning of its crank with the minimum fuss and bother at the transmitter end, and

INSTALLATIONS

By D. BOLLEN

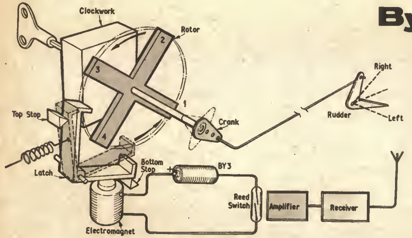


Fig. 1. Simple four-position sequential escapement — pulse operated

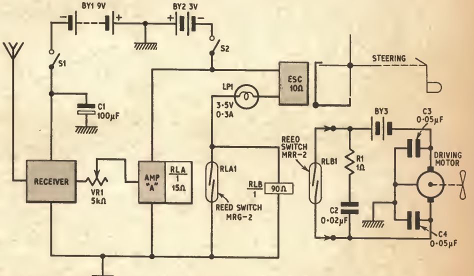
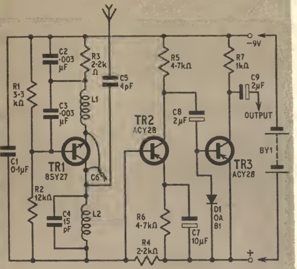
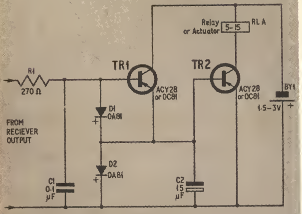


Fig. 2. Addition of stop-start circuit to steering unit

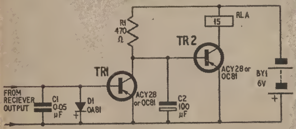
RECEIVER



AMPLIFIER "A"



AMPLIFIER "C"



These three circuits are reprinted from the previous series on *Miniature Model Control*. The Transmitter and Amplifier "B" will be given in Part Two

power is only taken from the battery for the duration of the pulse (typically 300–400mA).

It is only necessary to remember the simple sequence *right, neutral, left, neutral* to make the model go straight ahead or to left or right. Two or three fast pulses in succession will cause the escapement virtually to skip positions. Intermediate steering alignment can be approximated by fast work on the transmitter button, so that the escapement only remains at full right or left for a very brief time, sufficient to "twitch" the model in the desired direction; this is where the skill comes in.

The "Rising" Mark 1 four-arm escapement used with the prototype is manufactured by Rising and Schulz, Whissendine, Rutland, and can be obtained from many model shops. There is enough crank power available for a small boat or aeroplane, and the escapement has even been employed by the author to turn the steering wheels on a model car weighing over one pound. The clockwork motor will yield more than 150 complete revolutions of the crank on one winding.

INTEGRATED STEERING UNIT

The integrated steering unit, shown in the photographs, was made with the Receiver and Amplifier "A" module. Being only 3⅜in long, this unit is small enough to fit inside electrically powered model boats, cars, and tanks. All-in weight, including batteries, is 4 ounces, making the unit suitable for fairly small model aeroplanes. The main reason for having an integrated unit is that it can be quickly transferred from model to model, thus avoiding unnecessary duplication and expense.

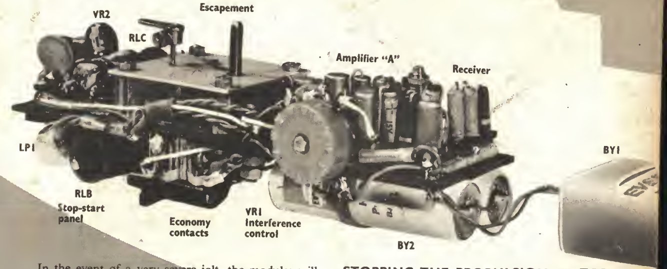
Propulsion motors tend to radiate considerable electrical interference, due to sparking on the brushes. One remedy is to wire two 0·05μF capacitors from the brush holders to the metal body of the motor, but even then interference may still be experienced, especially when the Receiver is positioned close to the propulsion motor.

Looking at the circuit in Fig. 2, interference control VR1 has been introduced between the Receiver output and Amplifier "A" input. If interference does cause spurious triggering of the escapement, VR1 can be backed off to just past the point where triggering ceases. There may be some slight loss of range, but not enough to prove troublesome.

VR1 also serves as an accessible connection for a pair of high impedance headphones, which are used to monitor Receiver operation and tone signal from the Transmitter.

Miniature model control receivers do not normally incorporate extensive supply decoupling but, when powered by low impedance Deac type rechargeable batteries, stability is adequate. However, if high gain transistors have been employed in the Receiver circuit there may be instability when it is coupled to a small layer built primary battery, such as the PP5. A simple cure for this instability, which lowers the effective battery impedance, is to wire a sub-miniature 100μF capacitor between the negative supply rail and earth. This is shown in the photograph on the underside of the mounting panel alongside BY2.

The steering unit, receiver and amplifier "A" modules are fixed to a mounting board by means of rectangular pieces of foam plastic, held in place with spots of glue. Although quite firm, the foam will absorb vibration from the propulsion motor, and guard against fatigue of soldered joints.



In the event of a very severe jolt, the modules will break free, and this avoids damage to delicate components. The crank can be attached either to the top of the output spindle (as shown in the photograph) or underneath close to the rotor.

High power cells are recommended for BY2 (for example, HP7), and are slung below the mounting board and held with a rubber band. Although a small box equipped with spring contacts could be made up to take the cells, soldered connections are more reliable. Pairs of cells can be quickly taped together and soldered, and it does not take long to connect such a battery to a set of miniature screw terminals on the mounting board. In the pulsed mode, the HP7 will give a surprisingly long life, and battery replacements are infrequent.

BY1 is not fixed to the mounting panel, but is used as ballast to trim the model. Similarly, switches S1 and S2 (Fig. 2) should be conveniently mounted on the outside of the model. BY1 is held by a rubber band, and the two switches can be attached to a sub-panel, designed for quick removal.

If the layout has been well arranged, it should be possible to transfer the integrated unit in a few minutes to another model. One further practical point; the linkage to the rudder or steering can be a piece of wire with a 90 degree bend at the end, to drop into one of the holes in the crank. This is prevented from jumping out again by a short length of tight sleeving slipped on the end of the wire.

STOPPING THE PROPULSION MOTOR

Having constructed and used the integrated steering unit, the enthusiast may wish to introduce other functions, such as "stop–start" and "slow reverse". One virtue of the unit form of construction is that changes can be made without dismantling the original modules.

The only real headache is in finding a bit more space in the model to take extra circuits and batteries. If the intention is to equip one particular model only, better use of available space can be made if the sub-units are dispersed, instead of being assembled in integrated form. It is amazing how much can be stowed away in a tiny model if circuits are built on individual panels less than 1 in square.

The stop–start control can be readily added to the steering unit at the expense of a space measuring 1in × 1in × ½in, and no extra batteries will be needed. Furthermore, this motor control can be used without any modification to the simple single tone transmitter.

To make the propulsion motor stop, it will be necessary to hold down the tone button on the transmitter. It may seem the wrong way round to keep the model stationary with a continuous tone, but the reason for this becomes apparent when it is considered that the model spends most of its active time going forward, and that stopping is only used for manoeuvring or in an emergency.

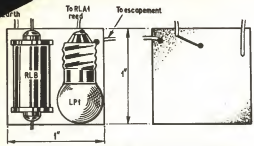


Fig. 3a. Stop-start panel topside and underside

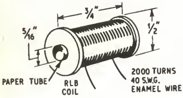


Fig. 3b. Construction details of RLB coil

"Stop–start" circuit details are included in Fig. 2. The bulb LP1 is introduced as a battery economiser. If the escapement is to be held on for long periods it will draw a continuous current of some 300mA, but with the bulb in series this is reduced to approximately 150mA. The resistance of a cold filament is much lower than that of a hot filament, therefore, a heavy initial current will flow through the escapement coil when RLA1 contacts close.

Before the bulb has time to warm up, the escapement latch is quickly pulled in, then the bulb glows and the current is reduced. The glow of the bulb is also a clear indication of correct circuit operation, and can be very usefully employed on single-handed range checks.

Unfortunately, although an attractively simple arrangement, the bulb does tend to slow down escapement speed and if pulses are sent in rapid succession, the bulb warms up and escapement current temporarily drops to a point where the latch is no longer pulled in. A preferred form of economy circuit will be given later.

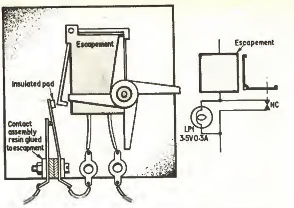


Fig. 4. Fitting economy contacts to the escapement

OPERATION OF "STOP–START" CIRCUIT

Since relay coil RLB (Fig. 2) is wired across the reed switch RLA1, a current will flow through this when RLA1 contacts are open. This is sufficient to close reed switch RLB1 and set the propulsion motor going. RLA1 contacts will therefore remain closed when there is no signal, but a continuous tone from the transmitter will hold them open.

R1 and C2 suppress the arc across the reed switch contacts when switching a heavy load; motor interference suppression capacitors C3 and C4 are also shown. Only the body of the motor is connected to a common earth point, and both brushes are left floating relative to earth. R1, C2, C3, and C4 should be mounted close to the propulsion motor, as permanent fixtures in the model.

"Stop–start" panel details are given in Fig. 3. The unit is very simple indeed, and can be mounted directly on the steering unit. RLB coil is wound with 2,000 turns of 40 s.w.g. enamelled wire, and bobbin constructional details are given in the inset diagram.

REED SWITCH RATINGS

A point well worth considering, which is related to size of model and equipment, is the current rating of miniature and sub-miniature reed switches. Miniature model electric motors have a high stalling current rating, sometimes well in excess of 1A, but the miniature reed switch, depending on type and contact material, has a typical long-life rating of 0·5A. If absolute dependability is called for, the switch rating should not be exceeded.

Although there is no reason why larger armature relays should not be used in bigger models, the reed does offer exceptional reliability and compactness, and an expected life of 100 million operations when not overstressed. Some standard size reeds, encapsulated in 2in glass envelopes, are capable of handling as much as 3A, and can be wound with exactly the number of turns and gauge of wire as a miniature reed in the same circuit. A bobbin for a standard reed need only be 2in long by ⅜in dia. for a 90 ohm coil.

When a heavy current is to be switched it is recommended that larger reeds are used, either to replace the miniature reed or as slave relays. Reed switches were carefully chosen for the circuits given here, bearing in mind cost and current loading. The type numbers in the circuits are for Hamlin switches, and these are obtainable direct from Flight Refuelling Ltd., Industrial Electronics Division, Wimborne, Dorset.

No hard and fast rules can be laid down when so much depends on individual application, but it is sometimes better to retain miniature reeds and replace the motor in the model with a low consumption propulsion unit, where high current is a problem. This will also bring a bonus in model operating time due to lower battery drain. A suitable motor for small boats or cars is the Microperm 2000, which has a stall current of 400mA, a running current of about 150mA, and measures 1in × $\frac{15}{16}$in diameter case size.

ECONOMY CONTACTS

For a very fast escapement speed with good "hold-on" economy, a set of contacts can be added to an escapement, as shown in Fig. 4. The contacts are normally closed when the escapement coil is not energised. When the latch moves, the contacts open and place LP1 in series with the escapement coil, roughly halving the current consumption. As before, the bulb will light up and can be employed as an indicator.

REVERSING THE PROPULSION MOTOR

Up to this point operation has been confined to one channel, using a modulated carrier only. It is possible to employ the unmodulated carrier virtually as a second channel for a separate function.

Amplifier "C" was originally intended for a 6V supply, but will work on a 3V source if an extra component is added. It may be remembered, from the earlier article, that Amplifier "C" is biased off by noise from the receiver. When a plain carrier is received, the amplifier switches on its relay, but does not respond to modulation.

Equally, Amplifier "A" does not respond to plain carrier, so there are two interaction free channels when both amplifiers are incorporated in a single unit.

The modified Amplifier "C" circuit is shown in Fig. 5. Enough free space exists on the amplifier panel to take not only the extra feedback capacitor C3, but a sub-miniature pre-set potentiometer VR1 and a 15 ohm relay coil identical to that used for Amplifier "A".

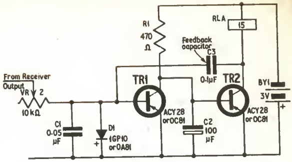


Fig. 5. Modified version of Amplifier "C" to operate from a 3V battery

Amplifier "C" panel, together with the "stop-start" unit, are attached to the "free" end of the escapement, opposite the Receiver and Amplifier "A". The complete control unit is 4½in long and weighs 5 ounces.

REVERSING CIRCUIT OPERATION

Fig. 6 gives the complete circuit. A changeover reed relay RLC has been introduced as a simple means of reversing the propulsion motor. BY3 is the main propulsion battery and the smaller battery BY4 is switched in by RLC1 to provide slow reverse when a plain carrier is received. As before, the motor is switched off by RLB1.

Pre-set VR2 allows Amplifier "C" to be trimmed for optimum results without the necessity for altering the value of C1 in Fig. 5 and, at the same time, acts as a series resistor so that the signal from the receiver is equally shared by both amplifiers.

Note the economy contacts on the escapement in Fig. 6, and the new values of suppressor resistors in the motor circuit. The reeds of RLB and RLC can be coupled to the motor circuit with a B7G plug and socket or similar midget connector.

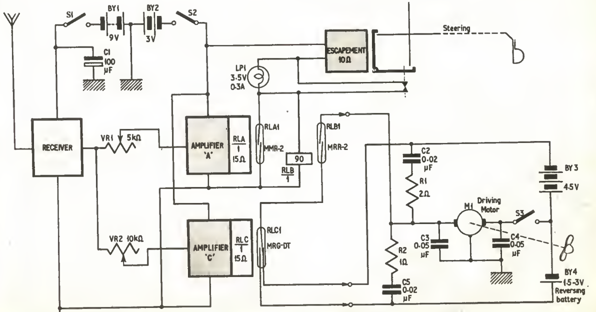


Fig. 6. Final comprehensive circuit with steering, stop and reverse

SETTING UP

Connect a pair of headphones via a $0\cdot1\mu$F capacitor between VR1 and earth. Set VR1 to its mid-position and close S1; the hiss from the Receiver should be audible. Check that the Receiver is responding correctly to a tone signal from the transmitter to the limits of range. Retune the Receiver if necessary and slightly advance VR1.

Next, switch on S2 and see if the escapement functions, and does not skip a position when the transmitter button is pressed. It is a good plan to set a small electric motor running close to the receiver to see if there is any interference. If the escapement starts operating of its own accord, back off VR1.

When "stop-start" is included, see that this functions correctly when RLB1 is coupled to a running electric motor. The bulb should light when the transmitter button is held down.

For Amplifier "C" the following procedure is adopted. Having first ensured that steering and stopping circuits are responding well to the transmitter, connect Amplifier "C" to S2 and connect VR2 to the receiver output. Advance VR2 until RLC just operates then back off VR2 slightly. The correct setting is when a very slight noise is just audible from RLC reed switch. A loud noise will denote that the reed contacts are opening and closing spontaneously.

This may be checked with an ohmmeter or a bulb and battery. Key the transmitter button with modulation switched off. If all is well, RLC will change over its reed contact to the reverse position.

Test the plain carrier range, which should be slightly more than half the distance obtained with tone signals. A table of current consumption figures is given as a guide for setting up.

OTHER INSTALLATIONS

It is hoped that the information given here will enable the reader to equip a model, and devise alternative arrangements, with different amplifier and reed switch combinations. For example, if the transmitter is modified to give two tones, at 1kHz and 5kHz, tuned Amplifier "B" can be placed in parallel with Amplifiers "A" and "C" to provide an extra channel, assuming that two more pen cells are added in series with BY2 to give the 6 volts necessary for Amplifier "B".

Table 1. CURRENT CONSUMPTION

	No signal (mA)	Tone (mA)	Carrier (mA)
BY1 Receiver	4	5	4·5
Amplifier "A"	2	150	zero
Escapement with economiser	zero	150	zero
RLB	30	zero	30
Amplifier "C"	7	5	150
BY2 total	39	305	180

The frequency determining ladder network in Amplifier "B" circuit (January issue) is tuned by capacitors C1, C2, C3. If $0\cdot02\mu$F capacitors are used, the amplifier will respond to a 5kHz tone. A $0\cdot02\mu$F low frequency blocking capacitor should also be added in series with the Amplifier "B" input resistor. As Amplifier "A" cuts off sharply above 2kHz there will be no interaction between "A" and "B" channels.

The circuit diagram of the transmitter and Amplifier "B" will be reprinted in Part Two of this article.

A motorised servo can be used in place of an escapement and the wiring diagram supplied with a new servo will show how to couple to various forms of amplifier output. Although bigger than an escapement, a sequential servo works in a similar manner and its greater crank power is suited to bigger or heavier models.

Several readers have queried the r.f. chokes used in the transmitter and receiver circuits. The prototype chokes were not, in fact, home wound. They were taken from valve type i.f. transformers. There is now available an excellent 97mA 1mH sub-miniature choke, scarcely bigger than a ½ watt resistor and this has been successfully used in both circuits. Manufactured by Painton, the choke is now available from Electroniques (Prop STC) Ltd., Edinburgh Way, Harlow, Essex, with the code number 58-10-0023-10.

Meetings . . .

INSTITUTION OF ELECTRICAL ENGINEERS

LONDON

Date: May 19
Title: Colloquium on "Advances in Measurements Brought About By Recently Introduced Semiconductor Devices"
Time: 9.30 a.m.
Address: I.E.E., Savoy Place, London, W.C.2

Tickets must be obtained from the Secretary, Savoy Place, London, W.C.2

Date: May 24
Title: The Postal Service and the Electronics Engineer
J. Piggott and T. Pilling
Time: 6 p.m.
Address: I.E.E., Savoy Place, London, W.C.2

SOCIETY OF ELECTRONICS AND RADIO TECHNICIANS

GLASGOW

Date: May 19
Title: Computers—A. Coppell (I.B.M.)
Time: 7.30 p.m.
Address: Y.M.C.A. Club, Bothwell Street, Glasgow

INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS

LONDON

Date: May 24
Title: Symposium on "Television Network Switching at the Post Office Tower"
Time: 5.30 p.m.
Address: 8-9 Bedford Square, London, W.C.1

READING

Date: May 23
Title: Astronomical Instrumentation
Prof. P. B. Fellgett
Time: 7.30 p.m.
Address: J. J. Thomson Physical Laboratory, University of Reading