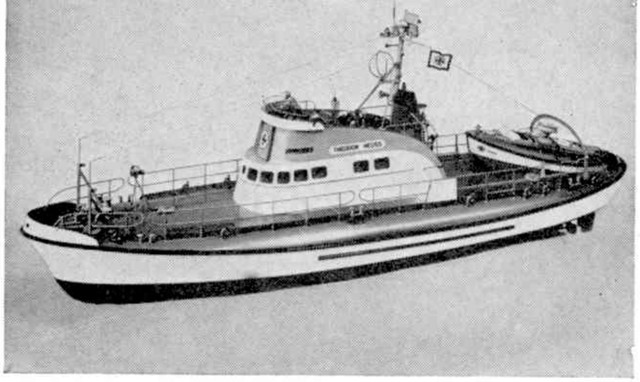


by **F. C. Judd A.Inst.E.**

RADIO

BUILDING models of aircraft, ships and motor cars is in itself a fascinating hobby and a well-made but otherwise stationary model can give much satisfaction to the maker. But how much more satisfying it is to make the model come to life, to almost place yourself behind the wheel of that model launch, to steer it and to control its engine as it glides across the water. You can do this with radio control, which becomes the link between you and the model and the means of conveying your commands.

Radio control can be applied to any working model, be it a boat or an aircraft or a motor car or even a stationary model which has working parts. This introduction deals with the principles of radio control, but later I shall be dealing with the construction of a scale model motor launch and a complete radio control system to steer it and control the engine.

How Radio Control Works

Let's begin with a simple explanation of remote control by means of electric current. The electric door bell is an easy one to understand and when the button is pressed at the front door, the electric current travels down the wire and actuates (remember that word) the electromagnetic mechanism of the bell. This may require long wires between the push button and the bell, but supposing we wanted to actuate the bell at some distance *without* long connecting wires.

Take a look at Fig. 1 which shows in (a) an ordinary bell circuit. In (b) however, the wires have been replaced with a RADIO LINK and the bell, together with its battery, is quite independent. It could, therefore, be placed almost anywhere within radio range.

The electric bell could actually be carried about and be made to ring when required, but how does the RADIO LINK do this? We begin at the 'transmitter' which is normally switched OFF by interrupting the high tension supply. When the switch or control button is pressed the transmitter is ON and radio signals leave the aerial. When the button is released the transmitter is OFF and no signals leave the aerial. Here then is a simple means of conveying COMMAND SIGNALS to the radio receiver.

When a signal is received it must be further changed and amplified so as to finally provide a strong electric current; strong enough to operate a RELAY. A relay is really an electromagnetic switch and is the final link in the chain

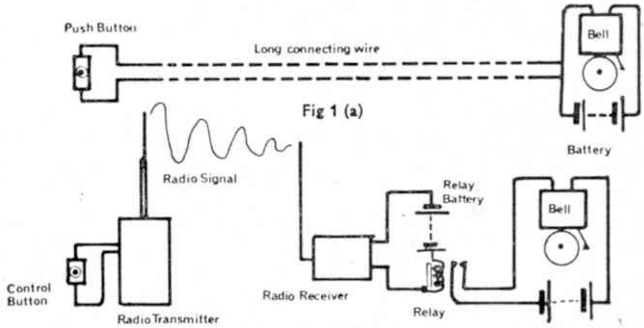
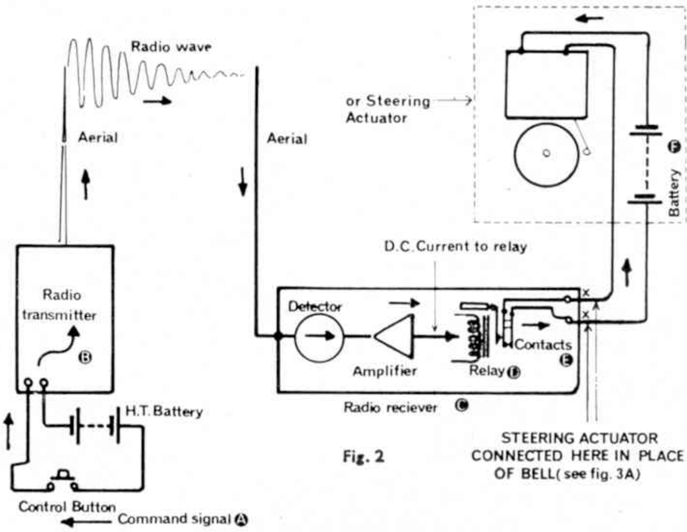
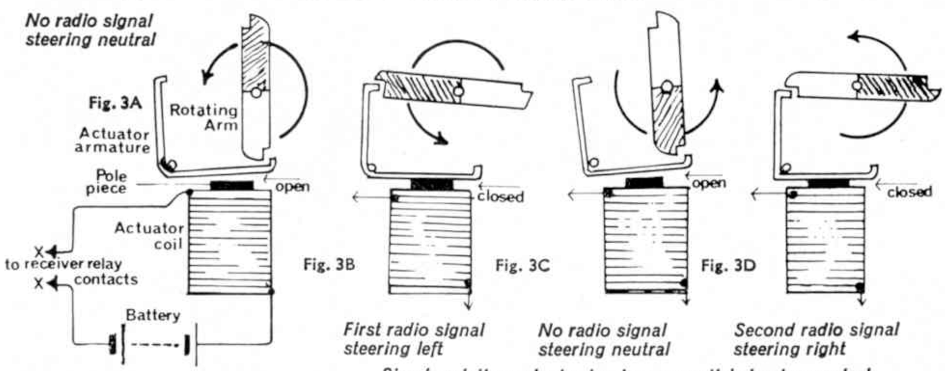


Fig. 1 (b)

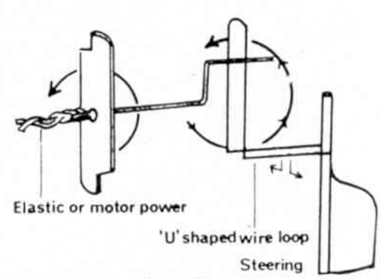
A comparison between an ordinary door bell (top diagram) and a radio controlled bell (bottom). Basically, the difference between the two circuits is the radio transmitter and receiver, which replaces the wiring in the ordinary door bell



The control signal path in a radio control system

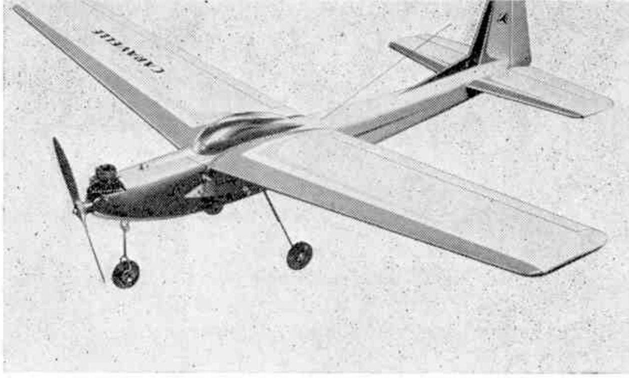


Simple rotating actuator to give sequential steering control



Note: The final position with no radio signal will be as first diagram, steering neutral. Above is shown the method by which the rudder is moved to the right or left by the motorised arm which is released by radio signals

CONTROL



of radio control. The contacts on the relay are used to switch the necessary current, to the electric bell in this case, which is obtained from a separate battery.

Let's go through the chain of operation again with the aid of Fig. 2. Starting at the control button (A) a command (bell on) is sent by pressing the button and holding. The transmitter (B) is, therefore, switched on and sends out a radio signal (called a carrier wave) for as long as the control button is held on. The radio receiver (C) now picks up the signal which is detected. This means that the signal is converted into D.C. (direct current) either by the receiving valve or transistor itself, or by a separate detector valve or transistor. The D.C. signal is, however, very small and may have to be amplified by further valve or transistor stages until it is strong enough to operate the relay (D). The contacts (E) on the relay then close and pass current from the battery (F) to the electric bell. The circuit is completed in just the same way as it would have been using long wires.

When the CONTROL BUTTON at the transmitter is released, the radio signal is stopped. Since there is no signal at the receiver to be detected and amplified there is no current passing through the relay coil. The relay will, therefore, open and cut off the electric current supply to the bell. Thus, by a radio control link, an electric bell can be set ringing anywhere within radio range. A model boat or aircraft can be controlled in exactly the same way without wires between the model and yourself.

Steering Control

The first and most important function is steering and for this we use a STEERING ACTUATOR (sometimes called a servo-mechanism). The most simple steering actuator has a moving claw that engages with a rotating arm which can be powered by twisted elastic (similar to the method used for powering model aircraft propellers) or by means of a small electric motor.

As in Fig. 3A the rotating arm is normally held stationary and in this position the steering is neutral (straight course).

When a radio signal is sent, current is applied via the relay contacts to the actuator whereupon the armature closes inward thus releasing the rotating arm which moves round a quarter turn as in Fig. 3B. It stops here because it is caught by the claw at the other end of the armature. By means of the mechanical linkage the steering has now been moved to provide a LEFT TURN and so long as the radio signal is 'held on' will remain in this condition.

When the radio signal is turned off, the armature will open again and release the rotating arm. This will now take another quarter turn and restore the steering to NEUTRAL as in Fig. 3C. Another radio signal will again operate the actuator and the process will be repeated, but this time, due to the mechanical linkage, the steering will be set for a RIGHT TURN as in Fig. 3D and remain so whilst the radio signal is held on. When the signal is turned off again, the steering will once more return to NEUTRAL.

So here we have a 'sequence' which means that one particular operation or command must follow another. In this case it is: radio off—steering neutral; radio on—steering left; radio off—steering neutral; radio on—steering right; and, finally, radio off—steering once more neutral. The sequence then repeats.

This very simple form of steering control is adequate for small model aircraft and boats but in recent years has been much improved upon by clockwork and electrically driven actuators. These have the same sequential steering control but in addition, allow control over an electric driving motor. One of these, the Kinimatic actuator shown in Fig. 4, will be featured in a radio-controlled model of a Chris-Craft Constellation motor launch I shall be dealing with next month.

Meantime if you would like advance details about this beautiful model and its radio control equipment call at your local model shop or write to: *Ripmax Limited, 80 Highgate Road, Kentish Town, London, N.W.5.* Ask for the Graupner catalogue plus the leaflets on Macgregor Radio Control equipment mentioning the article in M.M.

PART TWO

RADIO CONTROL

F.C.Judd, A.Inst.E. deals with constructing a radio-controlled boat . . .

THIS month I will deal first with building a model launch suitable for radio control and then go on to describe suitable driving and steering equipment. Why a model launch and not an aircraft? Well, in the first place, a model aircraft requires a good deal of 'flying' know-how and experience with radio control. Secondly, if you get a model aircraft up to a hundred feet or so and something goes wrong, you are likely to lose the aircraft completely or, if it crashes out of control, end up with a smashed model and probably radio receiver as well.

With a model boat there is little or no risk of losing it on the local boating pool if the radio stops working, or the propeller becomes fouled with weed. You might have to wait patiently for it to drift back, but there is, however, a very simple way of recovering a boat from the middle of a pond without waiting or paddling in for it. This I will explain when we get around to actually launching a radio-controlled boat.

Building from a kit of parts

Really keen and experienced modellers usually like to build their boats or aircraft from plans and the raw materials; some even design their own models. This is rather doing things the hard way but, on the other hand, can provide a good deal of interest and satisfaction. Nowadays there are excellent kits of parts for model aircraft, launches and ships, etc., available and of these I have chosen the Graupner kit for building a fine model of the Chris Craft Constellation.

The launch is 24½ inches long with a beam of 8 inches. (The original is a 40 foot craft with twin engines of 550 h.p. and capable of 40 knots.) My version of the finished model, built from the kit, is shown in Fig. 1. Most of the essential fittings are supplied with the kit, but I have also included such details as fend-offs (the small rope buffers that hang at the side), navigation lights and lifebelts, etc. The model is finished in blue and white with red on the underside of the hull.

There is no need here to describe the actual making of the model. Full plans and most concise instructions are included with the kit, which contains the necessary glue and decorations. The hull is prefabricated, but do pay heed to the warning about using non-cellulose glue and paint. The hull and the upper structure must be finished with oil-bound primer and paint only. Tools required—a fretsaw and a modelling knife.

The Driving Gear

Before I deal with the radio control equipment, there is the question of a suitable motor for the propeller. Any reasonably powerful electric motor will run the model at quite a good speed, so there is no need to use a diesel engine as one might for a model aircraft. The model shown in Fig. 1 was fitted with a Monoperm 2000 electric motor attached to what is called an inboard-outboard drive which also steers the boat. The complete motor and propeller assembly is called a Bongo 2. The propeller is driven by a right-angled gear system and is located within a circular integrated rudder. This part of the assembly can be turned through an arc of about 120 degrees, which is more than sufficient to steer the boat hard to port or starboard (left or right).

The photograph, Fig. 2, shows the location of the Bongo drive. The hole for the shaft is taken through the bottom of the hull about two inches in from the stern, as in Fig. 3. It is advisable to coat the shaft with a little of the special plastic glue supplied with the kit. No water must be allowed to seep up the outside of the shaft. It is also important to apply Vaseline to the inner shaft, the rotating part, for the same reason. The hole should be cut and the Bongo assembly mounted and fixed before any other part of the kit assembly is carried out.

Steering and Engine Control

The photograph of Fig. 2 also shows the location of the 'Kinematic' steering and engine control mechanism. The coupling arm between the Kinematic and the Bongo can be clearly seen. The long extension arm (A) on the Kinematic was later found to be unnecessary. A ten to fifteen degree movement either side of neutral on the Bongo rudder is quite sufficient to give full steering control, i.e., hard to port or starboard. The boat is quite fast when under way and produces a very realistic bow wave.

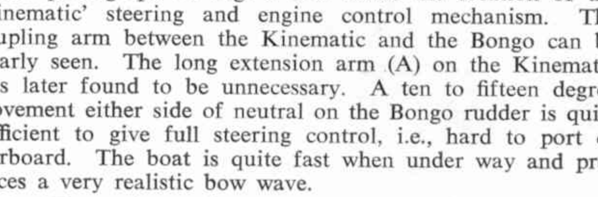
The Kinematic steering and engine control mechanism is a little difficult to explain, for it is quite complicated. It has a small built-in electric motor which operates from a separate 4½ volt battery. The motor can be directly controlled by a relay or a small power transistor in the radio control receiver.

The receiver I shall be describing uses a transistor as a means of passing current from the battery to the motor whenever a command signal is transmitted. The steering arm is

Data Panel—Inductance

Inductance is used in various ways in radio and electronics and most commonly in the form of tuning coils for radio receivers, radio frequency (r.f.) and low or audio frequency chokes and transformers. An inductance consists basically of a coil of wire and there are three ways in which it can be used.

If a magnet is plunged into a coil of wire an electric current will be generated in the coil, a phenomenon known as *Electro-Magnetic Induction*. If, on the other hand, a steady electric current is passed through a coil a magnetic field will be created around the coil. A change in current, however, will alter the strength of the field which in turn will induce in the coil a voltage tending to oppose the change being made. This is called *Self Induction* and the coil is said to have *self inductance*. The coil will



moved by a system of gears and a cam and pawl. The arm is, in turn, linked to the steering arm on the Bongo 2 drive. This turns the rudder to the left or right but each time through neutral. In other words, the Kinematic mechanism is self-neutralising. The sequence is therefore as follows: normal resting position neutral—no signal from transmitter. Long signal—rudder left, no signal—rudder restored to neutral. Second long signal—rudder right, no signal—rudder neutral. The sequence then repeats. Left or right rudder can be selected as required by going straight through the unwanted part of the sequence.

The Kinematic is also used to control the engine (electric motor) and to provide stop-start in the forward motion or stop-start in the reverse motion. The mechanism is so designed that a short transmitted signal takes the main drive gear only half way round, whereupon it promptly returns to neutral. The shaft attached to this gear carries a changeover switch that operates as the gear returns to neutral. This switch has four positions, one for each short signal given by the transmitter:

1. With the switch in the off position the motor is off.
2. Short signal—switch on—motor forward.
3. Short signal again—switch off—motor off.
4. Short signal again — switch on and polarity of motor battery reversed—motor running in reverse.

Finally, another short signal restores switch to the off position as in 1. The motor control is not affected by the longer steering signals.

Ready-to-assemble Kits

Not only have I built the model from the Graupner kit, but also the radio equipment, etc., as will be described in the next two or three articles. The finished model and its radio equipment have also been thoroughly tested too. However, it is only fair to add that radio controlled models is a rather expensive hobby. The radio equipment could, of course, be constructed from the necessary components bought separately. I venture to suggest, however, that in the long run it is much simpler and just as cheap to build from kits of parts which when assembled require no testing instruments other than a milli-amp meter. For instance, the radio control receiver, which I will describe next month, employs a printed circuit board and is simplicity itself to build and test (see Fig. 4).

On taking up radio and electronics as a hobby one cannot hope to build everything. If you cannot afford a radio control outfit now, you may at least learn something about this fascinating hobby in the hope of using the knowledge later when spending money may be a little more plentiful.

The Graupner kit for the Chris Craft Constellation launch costs 79s. 6d., while the Bongo 2 combined electric inboard-outboard drive and steering (with Monoperm 2000 motor) costs 45s. The Kinematic steering and engine control mechanism costs £3 12s. 6d.

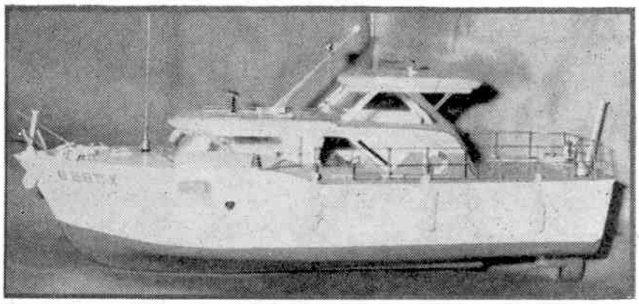


Fig. 1: The completed model Chris Craft Constellation motor launch.

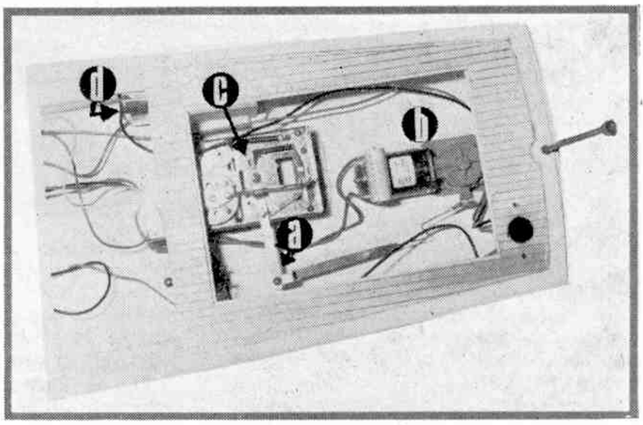


Fig. 2: (a) see text. (b) Location of the Bongo motor with integrated rudder/propeller. (c) Location of the Kinematic steering and engine control. (d) Battery (4½ volt) for Kinematic unit.

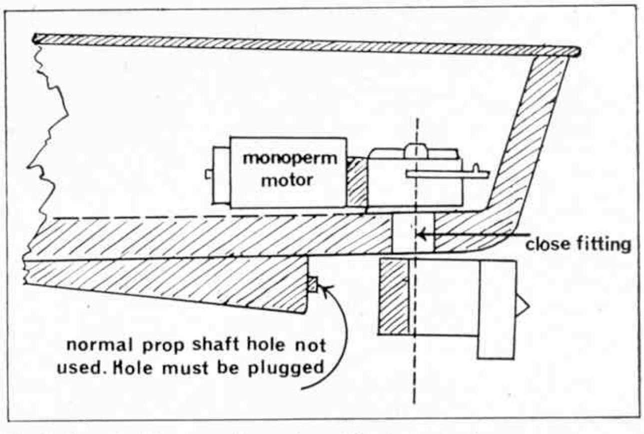


Fig. 3: How the Bongo motor and combined steering/propeller are fitted.

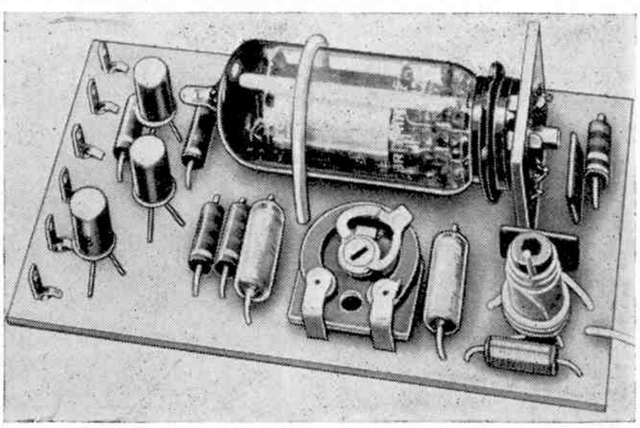
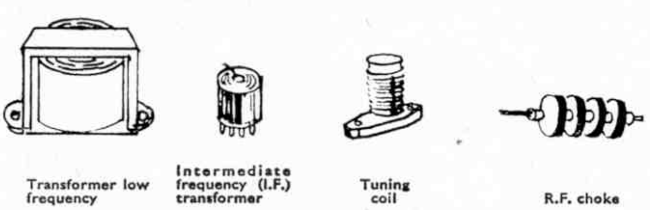


Fig. 4: The Ripmax Carrier Wave receiver Mk 2 for radio-controlled models.

have an inductance of 1 Henry (H) if the current through the coil changes at a rate of one ampere per second, the voltage appearing across the terminals being one volt.

The current change in one coil can also be induced in a second coil. The strength of the current in the second coil will depend on how closely *coupled* it is to the first. This effect is called *Mutual Inductance* and is widely used in radio receivers, amplifiers, a.c. mains power supplies etc. One of the most common applications of mutual inductance is in the transformer where the two coils, called the primary and secondary, are closely coupled to obtain the greatest possible transfer of power.

Coil circuit symbols and some typical shapes of inductive components are shown below.



FACTS ABOUT RADIO CONTROL

Part III by **F. C. Judd A.Inst.E.**

THE invention of 'printed circuits' has greatly simplified the construction of radio and electronic equipment, for all one has to do is to fit the components to the appropriate holes and solder the wires. Printed circuit boards consist of a paxolin board coated on one side with a thin layer of pure copper. The 'circuit', which is the actual wiring between the components, is first printed on to the coppered side with a special acid resisting ink. The whole board is then put into an acid solution, which dissolves away the unprinted parts of the copper. Finally, the acid resisting ink is washed off, leaving the bright copper connections all over the board. Holes for the components wires are drilled and the component values or numbers are printed on the reverse side.

The complete kit for a printed circuit radio control receiver is shown in Fig. 1. This is the Macgregor transistorised carrier wave receiver, which was chosen for the Graupner Chris Craft motor launch described last month.

The construction of this receiver is simplicity itself and the kit is, of course, complete with a comprehensive instruction booklet which contains all the necessary wiring and installation plans. However, to emphasise the simplicity of printed circuit construction, I have included Fig. 2, taken from the instruction book, for this shows the layout and physical size of this little receiver.

How the Receiver Works

The Macgregor carrier wave receiver is ideal for beginners and most suitable for medium-sized model aircraft and boats, for it weighs only $1\frac{1}{4}$ ozs. It is extremely sensitive because it employs a super-regenerative' oscillator - cum-

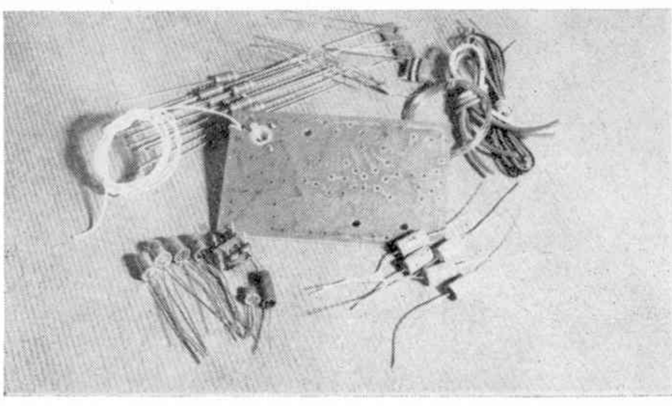


Fig. 1 The Macgregor printed circuit radio control receiver kit

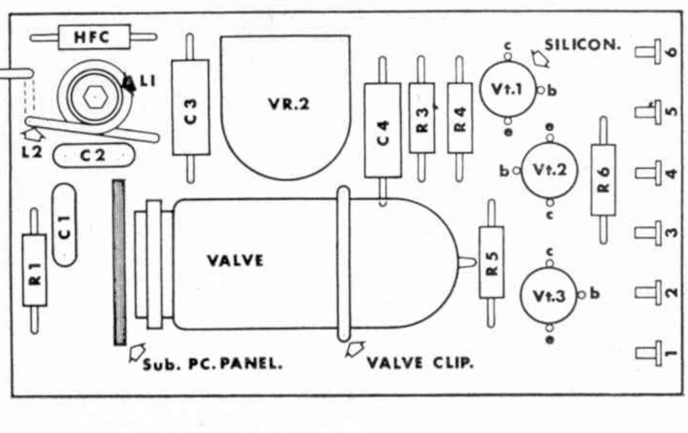


Fig. 2 Actual size of the Macgregor radio control receiver

detector. It will respond to the average radio control transmitter at several hundred yards and requires only an 0-5 mA meter to tune and test it for correct operation. Apart from being simple to construct and adjust, this receiver employs a silicon transistor instead of a relay to directly control a steering and engine actuator such as the 'Kinematic' system, also described last month and which is recommended for the Chris Craft launch.

The receiver will operate with any carrier wave transmitter and here I have chosen the Macgregor transmitter which also employs a printed circuit and is therefore easy to build. Both the receiver and the transmitter can also be modified for simple tone operation if desired at a later stage.

The receiver operates from dry batteries, which include a 1·5 volt cell for the detector valve heater, a 22 volt high tension supply for the valve and transistor amplifiers and a 4½ volt battery for the actuator. Current consumption from the batteries is quite low, so the receiver is economical as far as running costs are concerned.

Now a word about printed circuit soldering. This requires great care but a good deal of guidance on soldering is given in both the receiver and transmitter instructions. The makers say that many of the receivers sent to them for servicing have failed only because of poor soldering. It is therefore important to observe the rules of good soldering, which are the use of an electric iron with a 'pencil bit' about $\frac{3}{16}$ inches in diameter. The tip should be kept meticulously clean and tinned and only resin-cored flux should be used. This is supplied with the transmitter and receiver kits.

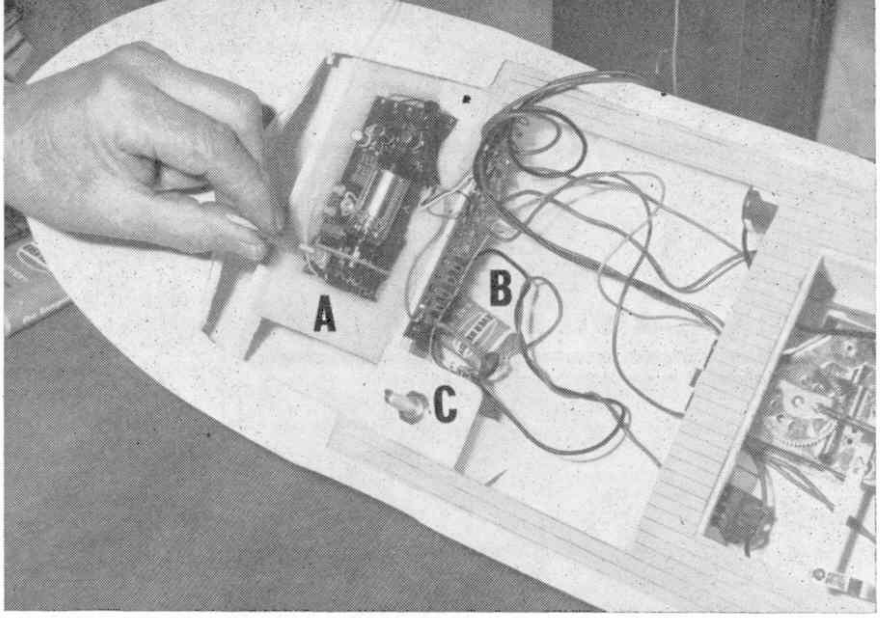
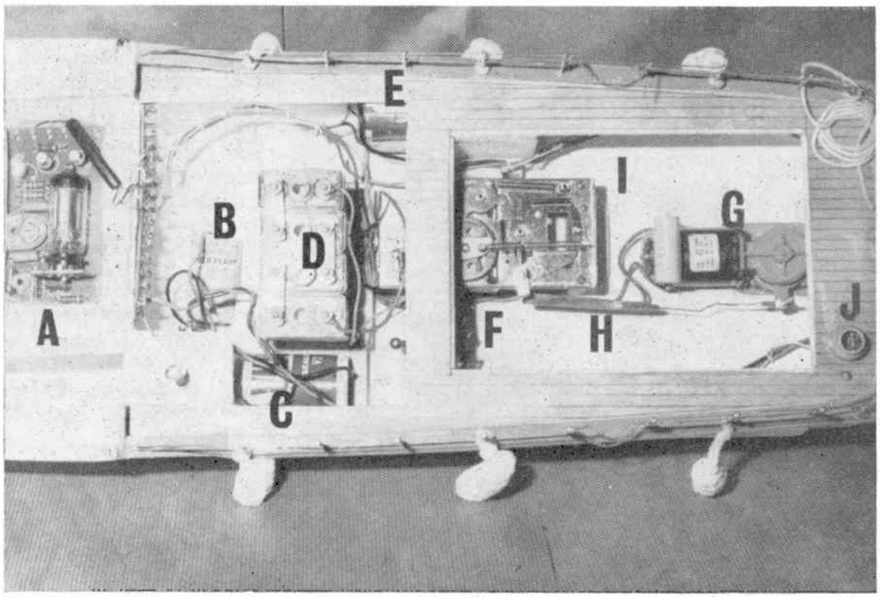


Fig. 3 The radio control receiver is mounted in a foam plastic block, glued between two strips of wood across the hull. A. Receiver. B. Tagstrip. C. Off/On switch

Fig. 4 The complete radio control system. A, Receiver. B, H.T. Battery (receiver). C, L.T. Battery (receiver). D, Drive Motor Accumulator. E, Actuator Battery (4½ volts). F, Kinematic Actuator. G, Bongo Drive Motor. H, Actuator to Steering Coupler. I, Motor Suppressor Capacitor. J, Meter Socket.



Installing the receiver

The photograph (Fig. 3) shows how the receiver is mounted in a block of foam plastic glued between two wood strips across the hull. One of the strips is part of the deck support, so it is only necessary to make one more and glue in position. The block of foam plastic is hollowed out with a model knife, just deep enough to let in the receiver. This will help protect the receiver from shock if the model should go head-on into a hard bank. Some boating ponds have concrete surrounds!

Just to the left of the receiver can be seen a solder tag strip, which is most useful as a joining and distribution point for the various connections to the batteries, actuator and on/off switch. These tag strips can be purchased from most radio component dealers and greatly facilitate the wiring. The receiver on/off switch is a double pole type and can be mounted at almost any convenient point near the receiver. (In the photograph, it is just to the right of the receiver, below the tag strip.)

The Kinematic actuator does not really need an on/off switch, but as a precaution against the receiver being accidentally left switched on, or short circuits, I included a switch for the actuator battery. The same applies to the drive motor, so a double pole switch was employed to break (a) one side of the 4½ volt actuator battery and (b) one side of the drive motor accumulator.

This brings me now to the distribution of the batteries and drive motor accumulator (or dry battery). It is most important that the position of the batteries are as shown in Fig. 4. Each battery can be held in position by pieces of balsa wood glued on to the hull, with special plastic glue only as supplied with the Chris Craft kit.

Before any radio or actuator tests are carried out, the model should have received its final coat of paint and preferably one coat of yacht varnish all over. If the painting has been completed, the model can now be floated in a bath of water to check that it does not list one way or the other. Squint along the top of the model to see if it sits upright in the water. Also, the waterline should slant slightly upward out of the water toward the bows. The position of one of the batteries may be altered a little to facilitate accurate trimming.

Next month I shall have a few words to say about the accumulator or dry battery for the Bongo drive motor and will also deal with the radio control transmitter and testing out the complete system. *Readers who contemplate taking up radio control are advised that a special Post Office licence is necessary for the operation of a radio control transmitter, but more about this later.*

The Macgregor Carrier Wave receiver kit Mk. 2 described in this article costs £2 19s. 6d. The Macgregor carrier wave transmitter Mk. 2, which will be described next month, costs £4 5s. 0d.

Radio Controlled Models

Part 4

BEFORE I deal with building and testing a radio control transmitter, here are a few notes about the G.P.O. Licence which is necessary before you can operate radio control equipment. The licence costs £1 and covers a period of five years. It is a special licence authorising the use of carrier or CW operation with or without tone or frequency modulation in the frequency band 26·96 to 27·28 megacycles with a maximum radiated power of 1·5 watts.

The licence also covers the second radio control frequency band of 464 to 465 megacycles with a maximum radiating power of 0·5 watts. This second band is a difficult one to operate in and is rarely used except by experienced radio control enthusiasts.

The licence is issued only for the purpose of controlling a model vessel, aircraft or vehicle and the apparatus used must not interfere with other wireless stations or receiving equipment. Further details concerning the radio control licence and an application form can be obtained from the Radio Services Branch, G.P.O., London, E.C.1.

A Transmitter for Radio Control

Transmitters used for radio control are fairly simple devices, usually consisting of an oscillating valve or transistor run at low power and employing a circuit designed to prevent the operating frequency from drifting outside the allocated frequency band. This latter requirement is most important since operation outside the band could cause interference to other sources. Some transmitters employ what is known as a self-excited oscillator with a reasonably efficient tuned circuit designed so that the transmitter will remain tuned as close as possible to its operating frequency. There are also self-excited oscillators which employ a quartz crystal in place of the tuned circuit and which are extremely stable and will not drift at all. This type of transmitter cannot be tuned to another frequency in the band without changing the crystal.

However, a well-designed 27 m/c transmitter, such as the Macgregor basic carrier wave model, is sufficiently stable for radio control although it employs a self-excited tuned oscillator. Like the 27 m/c receiver described last month it is assembled on a printed circuit board and construction from the kit is simplicity itself. The tuning coils and choke are ready wound and one has little more to do than mount the components as shown in Fig. 1 and solder up. Incidentally, this transmitter can be modified for tone control operation if desired, see Fig. 2.

The Macgregor basic carrier wave transmitter will operate very efficiently with the carrier control receiver. The Editor of this magazine will no doubt confirm this as he was present during some trials with the model Constellation launch, see front cover of March issue.

The assembly and wiring of the transmitter calls for little comment since the instructions provided with the kit cover everything including testing. However, do take care with soldering and connections to batteries, etc. Remember that one poorly soldered wire or a bad connection could easily stop the transmitter from working altogether.

Tuning the transmitter

The printed circuit board is mounted directly on to the front of the transmitter case as shown in Fig. 3. Before the transmitter can be used it must be tuned to within the model control frequency band of 26·96 to 27·28 megacycles. The first thing to check, however, is that the transmitter is working correctly by measuring the h.t. current. This should be between 12 and 20 milli-amps.

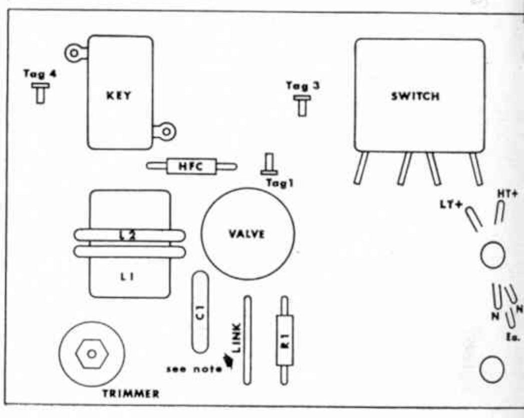
The approximate setting of the tuning capacitor for the model control frequency band is about one and a quarter turns from the closed position and will be accurate enough for preliminary tests indoors with the receiver. More accurate tuning can be carried out in conjunction with a receiver known to be correctly tuned or if this is not possible, most model and radio control shops will set the transmitter correctly in the band for a small charge.

Alternatively, you can return the completed transmitter to the makers who make a service charge of 5s. for the tuning. This does not, however, include the cost of return postage. Details of this service are given in the instruction book.

Testing the complete system

It must be assumed now that the receiver and control system have been installed in the model and that the transmitter is correctly tuned and operating. The first check then is to see that the receiver itself is functioning and then tune it correctly to the transmitter. As described in the previous articles, an 0-5 milli-amp meter is required and is connected as in the receiver instruction book. The transmitter is then switched on and the

Fig. 1. Component layout on the 27 m/c radio control transmitter printed circuit board. As can be seen, the layout is extremely simple and may be constructed easily by the amateur.



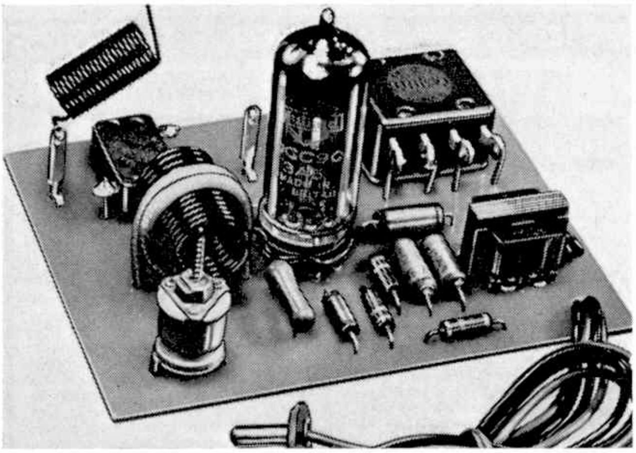


Fig. 2—The completed transmitter ready for fitting in its case. Note: the photograph shows the extra components for tone control operation which are not required for carrier wave unit.

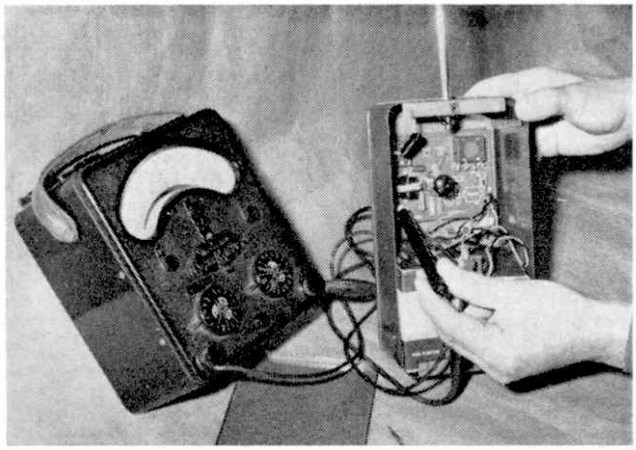


Fig. 3—The transmitter mounted in the case. An insulated trimming tool or a short stick of non-conducting material, shaped to fit the tuning capacitor, should be used for tuning as shown.

tuning procedure carried out exactly as the maker's instructions.

When this has been done and this includes the correct operation of the actuator, a long range check should be carried out by placing the model as far away as possible, say at the end of the garden, or at least one hundred feet away. Alternatively, the transmitter can be taken some distance away. The model itself should be set up so that the bongo drive is free to operate, i.e. the rudder section can move freely and the propeller can rotate.

The complete system can now be checked by going through the sequence required for steering—rudder left——neutral—right and return to neutral, etc. The engine control sequence of forward—stop—reverse—stop, etc., and, of course, other combinations such as engine start—left rudder, engine reverse—right rudder, and so on. The same checks should also be carried out at close range, i.e. transmitter only a few feet from the model.

Sailing the model

When, and only when, you are completely satisfied that all is working correctly, should the model be taken to the local boating pool. If possible, choose a pool which is shallow and not too big. Some parks have special small pools about 100 feet long for model boat enthusiasts and which are only a few inches deep. Don't put your model in a river as you may find the current strong enough to override the power of the motor. Do have someone with you for safety and to help recover the model should something go wrong. Watch out for dead leaves and weeds which can foul up the propeller and stop the model. If this happens in mid-pond, try reversing the engine for a few seconds to clear weeds or leaves.

If your model does stop in the middle of the pond and won't respond to the radio, there is no need to paddle in after it. Always carry with you a long piece of string; long enough to stretch across the pond. You take one end and your assistant the other and catch the model by gently dropping the string over it. Then walk on until the model is pulled into the side of the pond. Watch out for ponds with concrete sides as a model such as the Chris Craft Constellation with a monoperm motor can travel quite fast and you could damage the hull if it hits solid concrete at full speed.

Finally, a word about power for the driving motor. This can be a dry battery, of course, $4\frac{1}{2}$ or 6 volts, but it is more economical to use a re-chargeable accumulator. These are expensive to buy, but will last for years if properly looked after and always kept fully charged. At the end of a two or three hour run, the small accumulators used for models will be pretty well exhausted. Never leave an accumulator in this state or the plates will be ruined.

To complete this series of articles on radio control in which it has been possible to cover only one aspect of the subject, I have included details of two books which deal with radio-controlled models more thoroughly. From either of these, which are suitable for beginners, you can see that radio control is a fine and fascinating hobby that thousands of people all over the world practise and enjoy.

Next month, I will be writing about an equally fascinating radio hobby namely Shortwave Listening and which naturally leads to Amateur Radio Transmitting, the ambition of many who take up radio as a pastime.

Useful Books—suitable for beginners: Radio Control for Models, by F. C. Judd—Data Publications, 15s.; Radio Controlled Models, by R. H. Warring—Museum Press, 16s.

F. C. Judd, A.Inst.E.