

SIMPLE RADIO CONTROL

By H. G. Hundleby

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Introduction

Mention of this title to a friend, who is not only a keen radio flier, but also an electronics expert, provoked the comment: "Simple Radio Control! There is no such thing!"

Be that as it may, I have, in this little book, endeavoured to simplify the subject for those people who wish to indulge in a truly fascinating hobby for the first time.

In doing so, I am conscious of two facts: firstly, that my technical knowledge on the radio side is limited in the extreme; and, secondly, that a work of this kind cannot be entirely original.

In the first instance, my lack of radio knowledge is perhaps an asset rather than a handicap, as it has prevented me from blinding the beginner with science. I feel sure there is nothing between these covers that the veriest tyro will fail to comprehend.

On the second score, I have dipped freely into the fund of knowledge enjoyed by those enthusiasts who pioneered the postwar radio control movement in this country.

You, the reader, owe them eternal gratitude, for through their experimentation they have brought radio control within the scope of every aeromodeller. As the author, I owe a greater debt, for advice and assistance freely given, both on the flying field, and in the preparation of this book.

HARRY G. HUNDLEBY.

Chapter One

"I HAVE been an aeromodeller for a year or two, but my technical knowledge of radio is nil. Do you think it feasible for me to attempt a radio controlled model?" This is a question that arrives almost daily in the author's mail at the *Aeromodeller* Editorial Offices.

The answer lies in the affirmative, coupled with the suggestion that the task of producing a successful radio model will be considerably eased if the questioner acquaints himself with the simple basic principles of magnetism, electricity and radio. Suitable text books on these subjects can be found in any public library, and the writer found that titles intended for youngsters were most helpful, providing one is prepared to endure the ribald comments of more knowledgeable friends whilst digesting the "Boys' Book on Wireless".

Such is the present standard of commercial equipment that in the majority of cases it can be connected up as per makers' instructions, and will give reliable service. Providing, of course, that the user treats it in an intelligent fashion, and realises that it is delicate and precision equipment and must be handled as such.

An appreciation of the details of radio control equipment, a knowledge of its basic parts and an idea as to how they function in relation to one another, will serve to ensure successful and trouble free radio flying. Not forgetting the vital effect such knowledge will have on the pocket. One silly mistake or careless neglect of vital factors can add up to quite a sum of £ s. d., especially when scattered over your favourite flying field!

The whole purpose of this little book is to pass on the knowledge and experience gained by innumerable aeromodellers over the past few years, that it may serve to guide newcomers along the road (or should we say runway!) to successful

Basic Principles

and enjoyable radio control flying. Should you, for instance, make a bad error with the radio equipment on your first flight, or "freeze" on the control button at the wrong moment, the model need not spin disastrously to the ground, but can descend in gentle circles to fly again another day. However, more of this anon. First let us discuss the basic parts of a radio control unit.

The *Transmitter* is, as the name implies, an apparatus for transmitting wireless waves. It is a comparatively simple piece of gadgetry, usually enclosed in a metal case which contains batteries and an "ON" and "OFF" switch. Mounted on the case is an aerial and also a two-pin socket to which connects by means of a two-pin plug an extendable lead. The lead terminates in a push button type switch which the operator activates every time he wishes to send out a signal for control purposes (Fig. 1). When he presses the button a signal is radiated from the aerial at a certain frequency and is picked up by the next vital link in our control equipment the *Receiver*.

Before passing to the receiver let us dwell for a moment on this question of frequency. Frequency is a measure of the speed at which the current in our transmitter oscillates and is usually expressed in megacycles, e.g. 27 megacycles means the current is oscillating at 27 million times per second.

The frequencies allocated for radio control purposes are as follows:

26.96 megacycles to 27.28 megacycles
and
464 megacycles to 465 megacycles

The first waveband is the most extensively used, the second and higher frequency presenting technical difficulties in the way of equipment and for this reason little used.

The *Receiver* which is tuned to the same

frequency as the transmitter is so designed that on receipt of a signal it registers a change in anode current. This change in current is used to operate a gadget known as a *Relay* which is nothing more or less than a form of electrical switch.

We now reach the third stage in our sequence of events, where pressing the transmitter button has now resulted in the relay switch opening or closing, or to put it another way, switching "ON" and "OFF".

If we connect a separate electrical circuit to our relay it will in turn be switched on and off, and by including in this circuit a device known as an *Actuator* we can then operate the control surface of our aircraft. The actuator is an electro-magnetic cum mechanical device, sometimes clockwork driven but usually rubber driven, which provides the actual mechanical energy to actuate the controls.

All of the above mentioned basic parts of the equipment will be described in detail in later chapters. What is essential at this stage is that the reader grasps the main sequence of events. From *Transmitter* radiates a signal which is picked up by the *Receiver* (tuned to the same frequency). This results in a

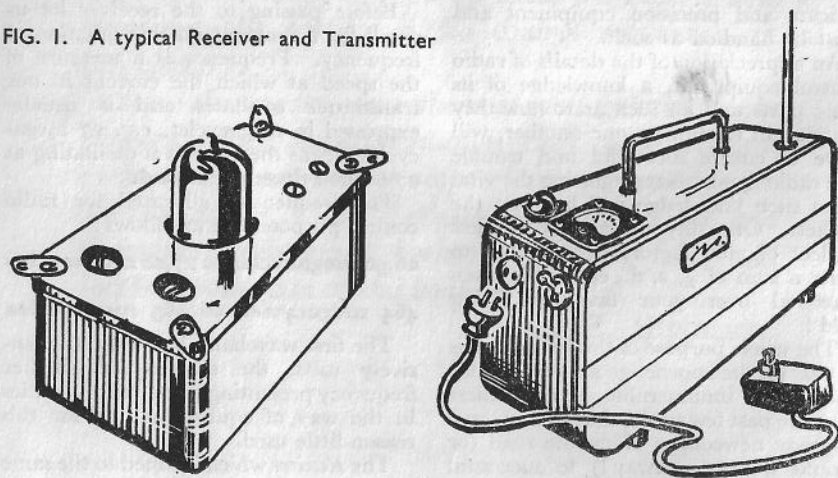
change in current within the receiver which is used to operate the *Relay*. The relay switches "ON" and "OFF" a separate electrical circuit containing an *actuator*, which in turn operates the actual control surfaces (see Fig. 2).

As this book is primarily intended for the newcomer to radio control let us dwell for a moment on a few general facts concerning present day equipment.

Firstly let us explode the popular fallacy that radio control consists of a model aircraft flown with all control surfaces such as ailerons, elevator, rudder, flaps in simultaneous use, coupled with complete engine throttle control as used by a pilot in a full size machine. Such comprehensive control is possible but is not radio control as known by the average aeromodeller. To produce equipment of this kind which would be infallible in operation costs many hundreds of pounds and requires the capabilities of an advanced radio technician.

Working on the principle that it is better to walk before you run, it is proposed to describe in this book only such equipment as can be built, operated and flown by the average aeromodeller. Consequently, we shall be dealing with what is known as Single Channel

FIG. 1. A typical Receiver and Transmitter



Equipment, which basically permits the operation of one control surface only. Without going into detail at this stage, let the author point out that it is possible to operate more than one control surface by our single actuator.

Simplicity is the keynote of the control method used by over ninety per cent.

of radio control fliers, and it consists of rudder control only. The sequence is as follows: Transmitter push button "OFF" gives NEUTRAL—"ON" gives LEFT rudder—"OFF" gives NEUTRAL—"ON" gives RIGHT rudder—"OFF" NEUTRAL—"ON" LEFT rudder etc., etc. Carrying on this

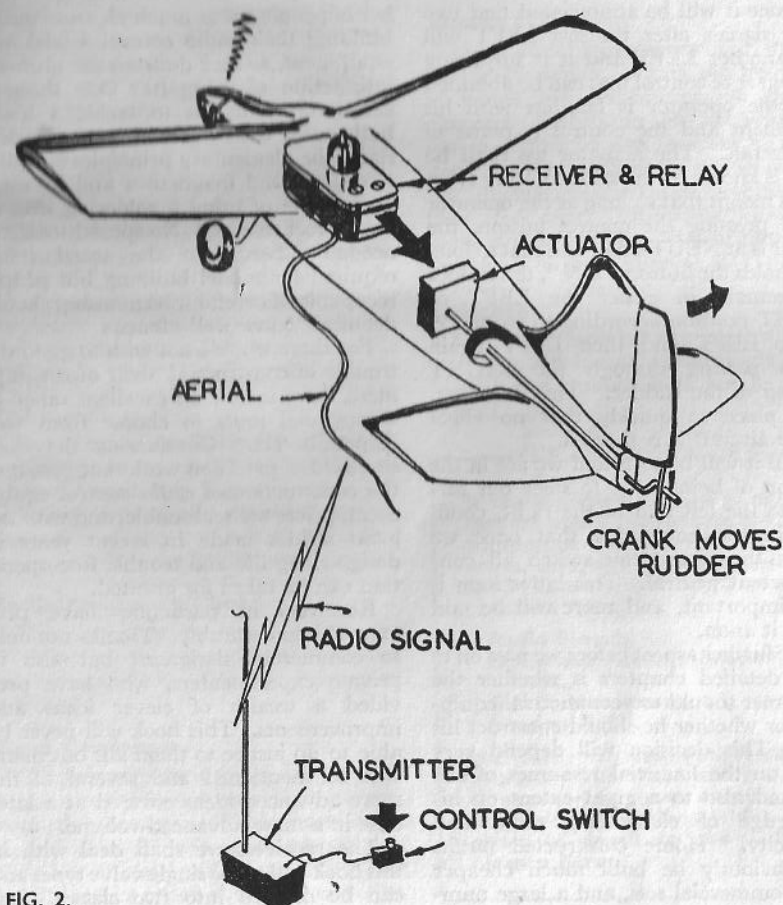
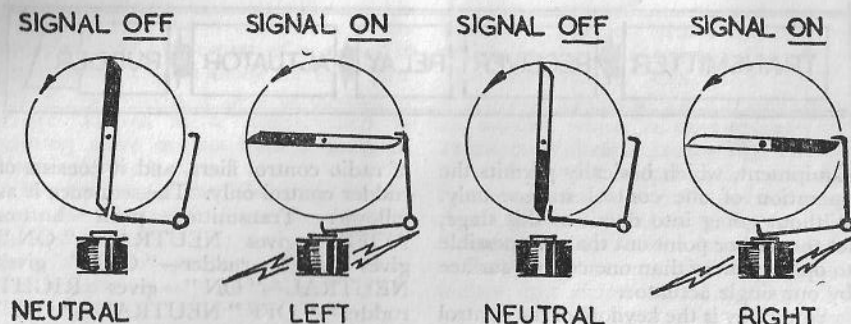


FIG. 2.



sequence it will be appreciated that two quick signals after the last LEFT will give another LEFT and it is surprising the degree of control that can be obtained once the operator is familiar with his equipment and the control response of his aircraft. The actuator we shall be using is known as the self-centering type, which means that so long as the operator is not pressing the control button, the rudder is at NEUTRAL, and that so long as he holds the button "ON", the rudder will remain in either the LEFT or RIGHT position according to sequence. To go LEFT and then LEFT again means passing through the RIGHT position of the rudder. This, however, takes place so quickly that no effect on the aircraft is registered.

Thus it will be seen that we are in the position of being able to steer our aircraft to the left and to the right, confident in the knowledge that once we release the transmitter switch all controls are at neutral. This latter item is most important, and more will be said about it anon.

One further aspect before we pass on to more detailed chapters is whether the newcomer should use commercial equipment or whether he should construct his own. This decision will depend very much on the financial resources of our tyro and also to a great extent on his knowledge of elementary radio and electricity. Home constructed outfits can obviously be built much cheaper than commercial sets, and a large num-

ber of people get as much pleasure out of building their radio control model and equipment, as they do from the ultimate satisfaction of flying it. One thing is certain and that is to tackle a home built outfit the constructor must understand the elementary principles of radio, electricity and magnetism and he must be capable of using a soldering iron in the correct manner. No special tools are needed other than the usual items required for model building but people incapable of careful workmanship should definitely leave well alone.

For those who do not wish to go to the trouble of constructing their own equipment there is now an excellent range of commercial units to choose from (see Appendix II). Considering the high standard of precision work that goes into the construction of radio control equipment, prices are reasonable, and with the great strides made in recent years in design, long life and trouble free operation can be taken for granted.

Receivers in particular have progressed immeasurably. Thanks not only to commercial designers, but also to private experimenters, who have provided a wealth of clever ideas and improvements. This book will never be able to do justice to them all, but many will be mentioned and several of the more advanced ideas covered at a later date in a more advanced volume.

The receivers we shall deal with in this book will all be single valve types and can be divided into two classes. Soft

valve or thyatron receivers, and hard valve receivers. These, in the opinion of the author, being the most suitable receivers for the tyro.

Although the author does not propose to deal with basic radio theory other than that directly connected with radio control, he does feel it necessary that the beginner should familiarise himself with the symbols most commonly used which are illustrated in Plates I & II together with actual photographs of the components. After all the symbols of the alphabet must be known before one learns to speak and write, and if the reader is to understand the few simple wiring and circuit diagrams in following chapters he must appreciate what the symbols represent. Let us briefly run through the various components and other commonly used terms, many of which are common to both transmitter and receiver.

Valve

This is the heart of any radio receiver or transmitter, its basic parts being the anode, the cathode and the grid. In valve symbols and valve socket symbols, the leads are always read clockwise, looking at the bottom. A typical example is shown in Plate II, facing page 17.

Relay

An electro magnetic type switch which is sensitive to current change. Various types are used (see Fig. 1 chapter IV) and they are usually classified by the resistance of the coil windings. Full description is given in chapter IV.

Radio Frequency Choke

This permits current to flow from the H/T battery to the anode of the valve but resists R.F. (Radio frequency) current.

Fixed Condenser

Condensers permit the passing of R.F. current but will not pass D.C. current from the battery. Their capacity is measured in Microfarads or pico-farads, also known as puffs, and they are usually colour coded as to their capacity.

Variable Condensers

Have a moving plate which increases or decreases the air gap between plates so changing the capacity.

Fixed Resistor

Its resistance value is measured in Ohms, and again a colour coding system is used for differentiating between values.

Variable Resistor

Also called a potentiometer and has a moving contact which permits adjustment of its resistance value.

Tuning Coil

This, used in conjunction with a tuning condenser, defines the frequency at which our transmitter, or receiver operates. Sometimes they are wound in plated copper wire as in Plate I, facing page 16, other examples are wound on bakelite formers and tuned by means of a dust iron core. Otherwise known as inductances, their inductance is measured in microhenrys.

Switches

Slide type switches are preferable for receivers, either single pole single throw (SPST) or Double pole single throw (DPST).

G.P.O. LICENCES

A transmitting licence is necessary for operating remote control equipment for model aircraft, boats, cars, etc. Licences cost £1 for 5 years and full details can be obtained from:

Radio Branch,
Radio and Accommodation
Dept.,
G.P.O. Headquarters,
London, E.C.1.

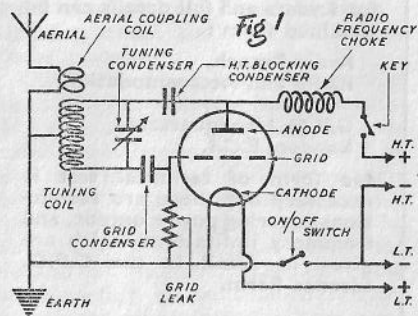
No form of technical test is necessary but there are restrictions covering power output, and frequency limitations which are given in detail in the G.P.O. Licence Form.

Chapter Two

THE transmitter is the one piece of radio control equipment that most of us take for granted and certainly it is the least troublesome to the tyro. If he purchases a commercial unit his sole task is to connect up the batteries, plug in the push button lead and aerial, and the equipment is ready for action. There is no wiring to be soldered and installed, in fact, the only possible mistake that could be made would be to plug the H/T battery leads into the battery in reverse, i.e. positive lead into negative socket and vice versa. Remember therefore, that the red terminal lead is H/T plus and the black H/T minus. The L/T lead invariably terminates in a two-pin plug which will only fit into the battery socket the correct way.

The man who is going to build his own transmitter has got to understand its working, and even the man who is going to buy his ought to understand its operation, so here we go on one of our rare dissertations into the "whys and wherefores".

In a transmitter the power from the batteries is used to generate an oscillating current that is radiated from the aerial. In fact, any high frequency oscillator is a transmitter in itself and only needs the installation of an aerial for it to be able to radiate oscillations.



The Transmitter

Before going any further, we had best understand the term "oscillations" which will also enlighten us as to what is an oscillator.

There are two kinds of electric current, alternating (A.C.) and direct (D.C.). The latter, D.C., is the kind produced by our batteries and flows steadily in one direction around our circuit. The other kind, A.C. however, flows in each direction alternatively at a definite time period, and does in the transmitters we shall be dealing with, oscillate at the fantastic rate of 27 million times per second. Each oscillation from positive to negative and back again is known as a cycle, hence 27 megacycles is the measure of our transmitter frequency.

There are many ways of converting the power of our batteries to radiation from the aerial and almost all of them need the aid of a valve. Study for a moment the simple circuit in Fig. 1., first making sure that you know what each symbol stands for by reference to Plates I and II. In the triode valve we have shown there is a Cathode or filament which is heated by our low tension (L/T) battery. There is the Grid, and above it the Anode or plate as it is sometimes called.

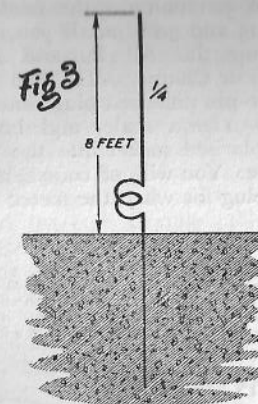
When the cathode is heated by the L/T current, Electrons are emitted or discharged. You will know by now from your study of basic text books that one characteristic of electrons is their affinity for a positive charge. If a sufficiently high voltage, i.e. high tension (H/T), is connected with the positive to the anode and negative to the cathode, the electrons will be drawn to the anode and will flow round the circuit back to the cathode. A milliamperemeter in the circuit will show a flow of current (Amperes) from H/T positive to the anode because the electron flow is the opposite way round to the current flow.

The higher the anode load, the

greater will be the current flow up to the maximum emission of the cathode. In other words, the current will vary according to the H/T voltage, and it can also be varied by applying a voltage to the grid. In fact, the higher the negative voltage applied to the grid, the lower the current in the anode circuit. If enough energy can be fed back from the anode to the grid it will build up into an oscillation.

The H/T is fed to the anode through a radio frequency choke (R.F.C.) which allows D.C. to pass but resists the radio frequency (R.F.) current. The condenser next to the R.F.C. allows the R.F. to pass but stops the H/T. The tuning coil and condenser determine the radio frequency at which the circuit oscillates. The grid condenser and grid leak provide a bias on the grid, this bias being a voltage that sets the operating conditions of the valve and is generated by the oscillations. If the circuit does not oscillate there will be no bias and the anode current will rise. In fact, one way of checking whether a circuit is oscillating is to touch one of the grid connections and observe via your meter, the rise in anode current.

We now take our circuit energy or power to a radiator, otherwise known, as an Aerial. A lead is therefore taken from the Tuning Coil via a coupling coil to the aerial the other end of the coupling coil being earthed. In the same way as we match a mechanical motor to the drive by gearing, so our aerial load is connected to the oscillator coil geared or stepped down. The aerial itself has to be matched to the supply frequency, and theoretically would consist of two arms each one quarter of a wavelength long, with coupling coil in the centre (Fig. 2). This at the required frequency would mean an aerial sixteen feet long, and so a compromise is effected by using a quarter wave aerial only, which with an earth connection, is



almost as good (Fig. 3). The standard quarter wave dipole, as it is called, is in almost universal use for model control equipment and usually consists of short lengths of copper tubing, which join together to make a whip type aerial approximately eight feet long.

The study of aerials would fill a book in itself so it is not proposed to delve into the subject here. From a practical viewpoint it is, however, important that aerial connections are sound. The joints between the aerial units should be kept clean, and they should also be tight to assure a good contact. The socket which supports the aerial is invariably bolted to the transmitter case, and by virtue of the leverage applied to it, has a habit of loosening its bolts. The socket should therefore be inspected from time to time as a loose aerial can definitely cause trouble.

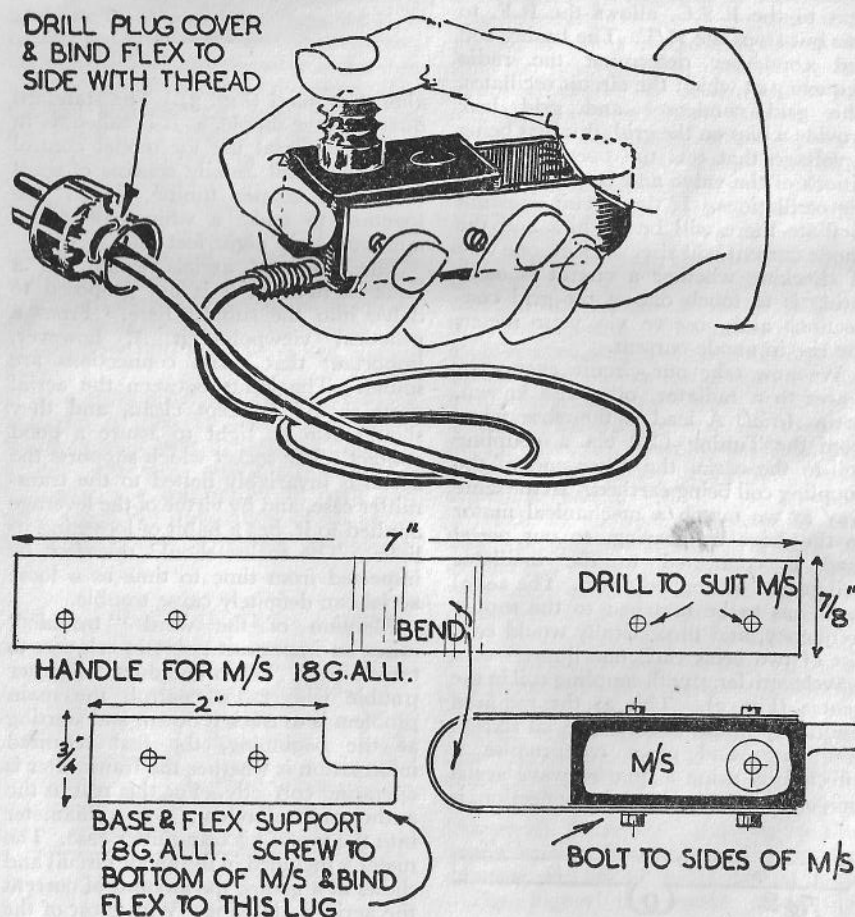
Mention of the word "trouble" raises an important point in relation to transmitters. When one does encounter trouble with radio control, the main problem is to track it down, and starting at the beginning, the first required information is whether the transmitter is operating correctly. For this reason the author always builds a 0-50 milliammeter into the top of his transmitter case. The meter is included in the anode circuit and shows at a glance the amount of current the aerial is drawing. With most of the

circuits in common use the reading is between 25 and 30 m/a. If you intend making up the All Purpose Meter described in Chapter VII, then fit it with a two-pin polarised plug connected to the 0-50 m/a scale, and build a similar polarised socket into the transmitter case. You will, of course, need a shorting plug for when the meter is not in use.

A few final tips relating to transmitters in general: *Don't* travel with your transmitter on the floor of the car or in the luggage boot. The jolts and jars received will not improve efficiency, and may well put it off the correct frequency. Better to travel with it on the seat which absorbs harmful vibration even if it does mean the wife walking!

Don't use balsa cement for securing

FIG. 4.—Keying leads usually receive more than their share of fair wear and tear. The drawing below shows a useful modification to the ordinary micro-switch which ensures comfortable handling and fracture-proof joints. If you balk at the small amount of extra work it entails then consider what happens when a keying lead shorts!



aerial coil or tuning coil windings as, being a celluloid compound, it is likely to affect frequency. Instead, use the proper shellac with low loss properties which can be readily obtained from any reputable radio dealer.

Do ensure that mechanical rigidity is good on your transmitter. Construct on a heavy gauge rigid chassis, and keep the aerial coil away from the metal case by at least the diameter of the coil. Make sure also that all leads are kept clear of the tuning condenser.

Don't use mica compression type condensers for tuning the aerial circuit. Air spaced types, such as the Phillips Beehive condenser, are far better, but

you should remember to seal these with shellac once the unit is tuned.

Don't leave the aerial coupling coil loosely fixed. Again seal with shellac once it is wound tight.

Don't leave vibrator packs or similar power supplies unscreened.

Do take great care of your keying lead, which is better made of stout rubber-covered two-core flexible cable, rather than the light plastic-covered flex that so many people employ. See that it has fracture-proof connections at each end, as per Fig. 4, which also shows a useful modification to the normal micro-switch, that makes for more comfortable handling.

Chapter Three

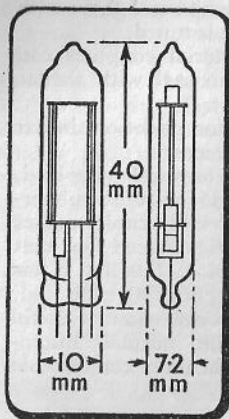
The Receiver

OF our Airborne equipment, the Receiver is the most important item. As part of the payload of the model, it is necessarily small in size and light in weight. It consists of an insulated panel on which the components are mounted, and very often is enclosed in a plastic case for protection. For mounting purposes, either tags or holes are let into each corner of the panel through which rubber bands can be looped.

As this is essentially a book for the newcomer to Radio Control we shall only be dealing with what are known as single channel receivers which, as the name implies, permit only one channel of operation at one time. Or, to put it another way, can only receive one signal at a time. They can be classified into two basic types. Those using *hard* valves and those using *soft* valves.

A hard valve might be described as a hardy valve in that it enjoys an almost unlimited life. It is a valve from which

all air has been exhausted or, if we can be excused a literary liberty, a valve filled with a vacuum. It is constant in characteristics throughout its working life, which is the main feature distinguishing it from a soft valve, otherwise known as a gas triode, or a thyratron. In the immediate post-war years experimenters were striving to produce single valve receivers that would give sufficient current change to operate a relay. This was no easy task using hard valves and the advent of the gas triode made the problem easier. Messrs. Hivac, well-known as manufacturers of miniature valves for deaf aid purposes, were prevailed upon to produce a miniature gas triode known as the XFG₁. It was a remarkable achievement in valve manufacture, being only 4 cms. long, weighing 4 grammes, and certainly made possible the construction of extremely light and compact receivers. Such valves as the XFG₁ are filled with an inert gas instead of a vacuum, and



This general arrangement drawing shows the minute size of the XFG1 sub-miniature gas filled valve. The valve is always mounted flat on the receiver panel and a special valve holder is available. A rubber strap is essential for securing the valve in position, owing to the fragile nature of the pins.

when the filament is heated the gas greatly stimulates the electron flow, thus permitting the valve to handle a larger current change. As with most things in life, one pays for the improved performance and the gas content gradually deteriorates until eventually the valve ceases to function or, to use a common expression, "Goes Soft". However, properly handled the XFG1 is a most useful valve and will last at least a year's continuous flying, and maybe longer. For those people who wish to build "Baby" models, it is ideal, making possible the construction of truly miniature receivers, such as the example designed by Geoff Pike and described in Chapter X.

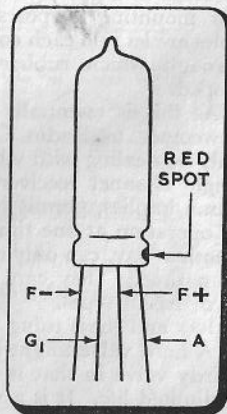
The current change on an XFG1 set is anything from 1.0 milliamps to 1.5 milliamps, which is ample for relay operation. It uses only 45 volts H.T. and 1½ volts L.T. One disadvantage of the gas triode is the change of characteristics that occur during its life, and this often results in people discarding the XFG1 valve before it is really expended. As the valve grows older the tuning capacity needs to be increased and the coil decreased. This is not difficult and can be done in two ways. Either by using a 3-30 pf. tuning condenser and by increasing this as the valve ages, and taking turns off the coil to maintain correct frequency at the same time;

or by using a tuning coil with an adjustable dust iron core which can be withdrawn as required. This latter method is probably the best of the two.

The first golden rule with the XFG1 valve is to set your anode current to the minimum possible figure as obviously the less current drawn the longer the life of the valve. Most commercial receivers give the operating current required. So, if the stated idling current should be 1.6 milliamps, make sure you do not adjust it by means of the variable resistance to 1.8 milliamps. Your valve is just like your car engine. If you run it flat out all the time its life will be short but a gay one! Detailed tuning instruction for XFG1 receivers will be found in a later chapter. Most of the commercial receivers incorporating the XFG1 make provision for the ageing of the valve. The E.C.C. 950 incorporates a pre-set condenser in the tuning circuit that can be altered, the tuning being carried out by the method previously described, i.e., an adjustable dust iron core in the coil. The E.D. "Boomerang" has three different aerial connections, again to compensate for changing valve characteristics.

One sometimes finds the odd valve that refuses to give a complete current drop when brand new. It will usually be found that a very short aerial, or in some cases, no aerial at all is the answer

Every XFG1 has a red spot on one side which indicates the anode pin is on that side. When purchased, the pins, which are only copper wire, are over long. They should be trimmed, so that when inserted in the valve holder they just protrude at the base. Pins should also be scraped to ensure a good connection.



here. Alternatively, the valve can be "run in" at a deliberately high anode current for a short while. It will then revert to more normal characteristics.

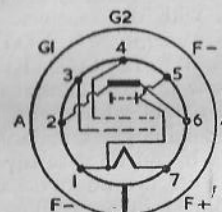
All the above advice concerning the XFG1 valve may give the reader the impression that they are temperamental, even unreliable, but this is far from the truth. One does get the odd valve that shows characteristics different from its fellows, but in the majority of cases they behave in a normal manner, and will give at least a full season's use, and in some cases, two or three flying seasons.

So far we have made little comment

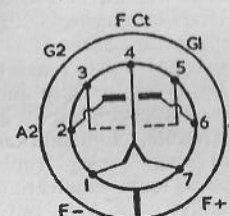
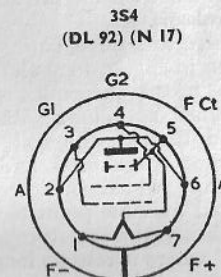
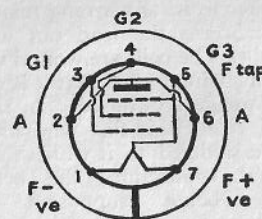
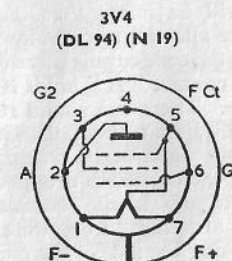
about hard valve receivers, which, in the main, use a single valve. Types commonly in use are the 1S4; 3S4(D.L. 92) (N.17); 3V4 (D.L.94) (N19); 3A5 (DCC90). They all operate on 1.5 volts for the filament, or L.T., and vary in need with regard to H.T., from 45 to 90 volts. All those mentioned have B7G valve bases, with seven pin sockets. Valve base connections should always be read from underneath with the wide space between pins at the bottom. Reading clockwise we then start from Pin 1 on the immediate left of the wide space round to Pin 7 on the right.

VALVE BASE DIAGRAMS

Below are some of the most commonly used hard valve base diagrams. All of these use B7G Octal bases.



1S4

3A5
(DCC 90)3Q4
(N 18)

Chapter Four

The Relay

SOMEHOW or other the relatively small current change that takes place in the receiver as a result of a signal from the transmitter has to be converted into sufficient mechanical energy to operate the control surfaces. The Sensitive Relay as it is called provides the link between these two phases of operation. As we have said in a previous chapter, it is basically a form of electro magnetic switch which, operated by a weak current, can open and close contacts carrying the more powerful current needed for the actuating of the control surfaces.

There are three basic types of relay shown in Fig. 1, they all operate on the same broad principle which can be explained as follows: When current is passed through the coil the iron core becomes magnetised and attracts the armature which is either balanced or pivoted at some point along its length. This brings the armature against contact "A" where it rests so long as current is maintained through the windings of the coil. When this current falls the return spring pulls the armature away from the core so that it meets contact "B", thus completing the separate actuator circuit. It will be appreciated that so long as the requisite amount of current is maintained through the relay coil then the actuator circuit is dead, and that as soon as the current falls below this point then the actuator circuit is "live". It will be noted that the armature is never allowed to actually make contact with the core or pole piece of the coil, and that contact "A" holds it just proud of same. There is a sound reason for this, namely, that the pole piece retains a certain amount of residual magnetism after the current is dropped. Enough in fact to prevent the return spring pulling the armature free were it actually touching the face of the core.

Generally speaking, the resistance of

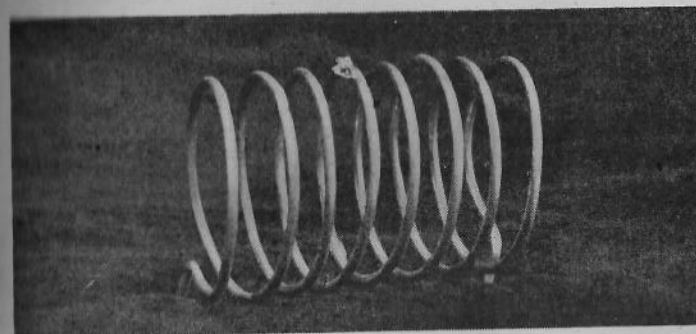
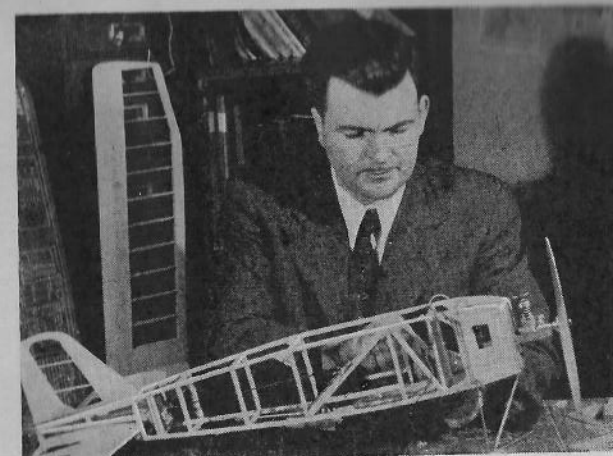
the coils determines the current values at which we operate the relay. For one milliampere and under the coil resistance is approximately 5,000 to 12,000 ohms, between one and two milliamps 3,000 to 5,000 ohms and five milliamps 2,000 to 4,000 ohms. It will be seen that the higher the resistance of the coils, the more sensitive the relay, and the lower its operating current.

In all commercial sets the relay is adjusted by experts before leaving the factory and you will invariably find the "IN" and "OUT" readings given on a card supplied with the receiver. The first thing to remember is NOT TO INTERFERE WITH THE RELAY unless you know for certain that it has been knocked out of adjustment, or in the case of a secondhand set, maladjusted in some way. If you must satisfy your curiosity as to its operation do so by means of your milliamperemeter as described in Chapter VIII but even then, if your figures differ from those on the card you would be well advised to check your meter before tampering with the relay. The first reaction of the R/C tyro when his set misbehaves is to reach for a screwdriver and prod heartily in the direction of the relay, which only lands him deeper in trouble. Time and again the author has seen "relay trouble" turn out to be a loose connection or something equally as simple. Once again—LEAVE THE RELAY ALONE until all other sources of failure have been thoroughly checked.

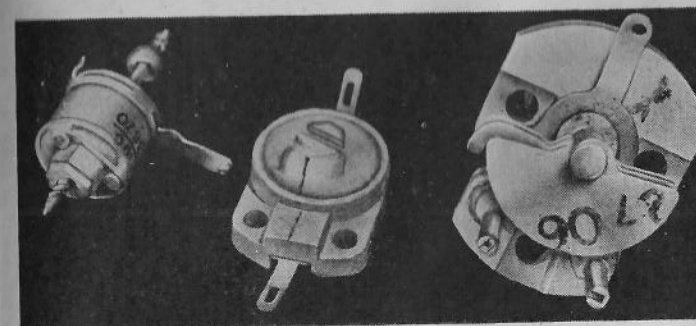
One further word of warning relating to relays concerns the lead out wires from the coils. The coils are wound with extremely fine wire, so fine that it is very prone to damage if misused. In most commercial relays this fine wire has a stouter wire soldered to it which forms the external connection, the actual coil wire being supported by insulating tape wound round the coil.

The Author working on the radio installation in a "Spurky" fuselage. Note that the fuselage sheeting has yet to be completed. For ease of working, this is best done after the wiring has been installed.

Below, are typical components with their appropriate symbols, as used in circuit diagrams.



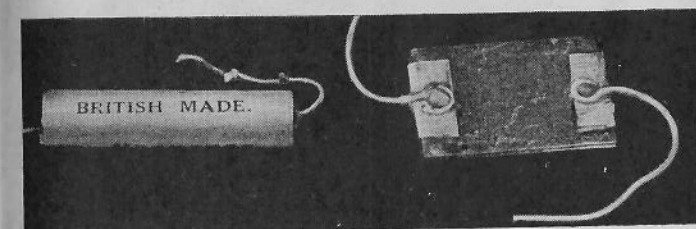
TUNING COIL



TUNING OR



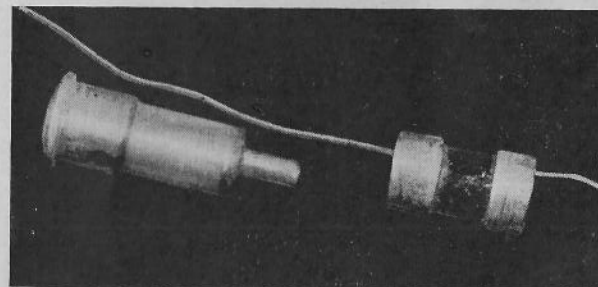
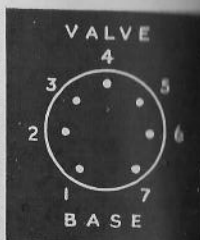
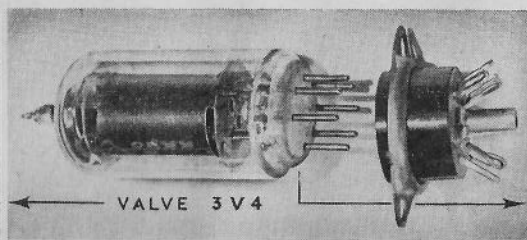
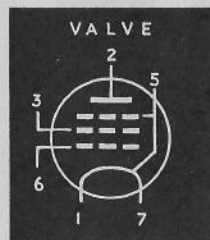
VARIABLE CONDENSERS



FIXED



CONDENSERS



CRYSTAL DETECTOR



OR RECTIFIER

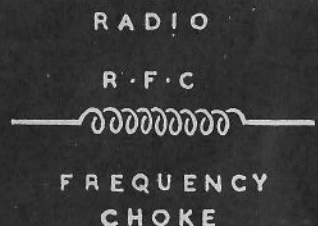
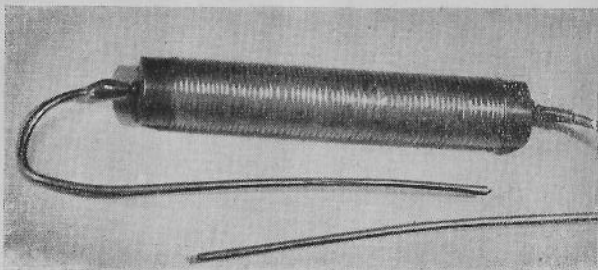
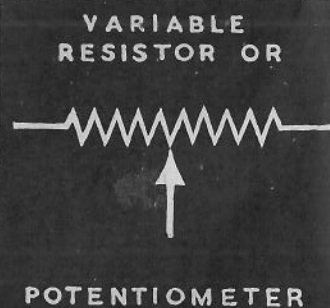
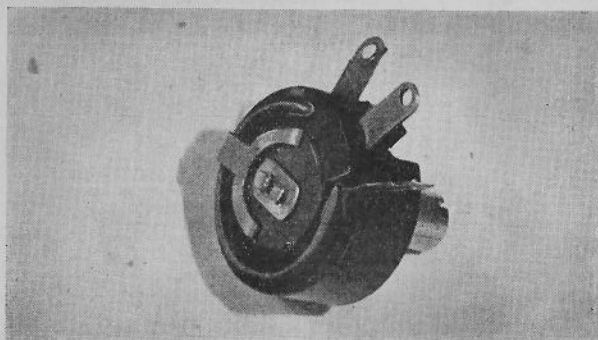
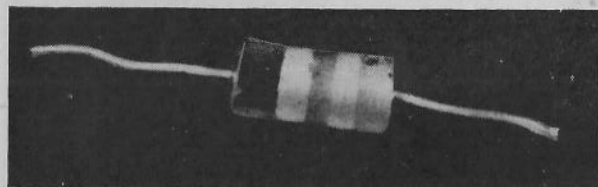


PLATE II

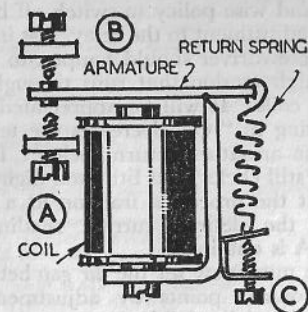
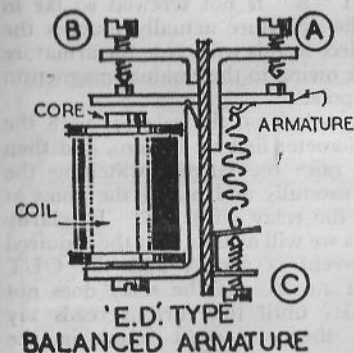
Great care should be taken when soldering coil connections as an iron that is too hot is quite liable to melt the joint inside the insulation, or even the fine gauge wire itself.

When building your own equipment do not let weight considerations influence the choice of relay. Better an extra ounce of weight and reliability than the reverse. Many people make the mistake of lightening relays such as the High Speed Siemens type and the Sigma SCR 532 to the extent of re-mounting them on thin gauge paxolin bases. When subjected to torsional stress in mounting these bases twist and have sorrowful effects on relay settings. Always ensure that your relay is rigidly mounted.

Let us now study the different types of

sensitive relay, not only the commercial relays produced by firms specifically for radio control purposes, but also the excellent relays sometimes available from war surplus dealers at modest prices. Fig. 1 shows a Siemens relay of the reed type with armature attached to a long reed which is fixed one end, the other passing between the contact points. A very cunning spring with tension adjusted by means of a knurled screw applies sufficient pressure on the armature to lift it clear from the right hand pole of the magnet. The photograph in Plate VII shows a modified Siemens relay of this type which can be obtained on the surplus market for around 13/6. Make certain when buying that you get the correct resistance coils.

Most of the commercially available



'E.C.C.' TYPE

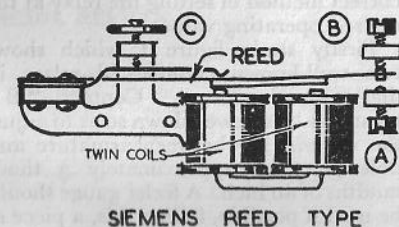
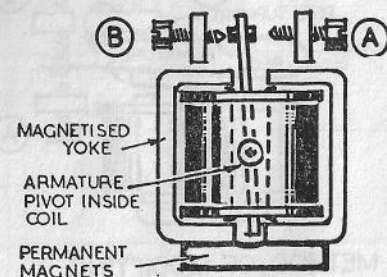


FIG. 1. SENSITIVE RELAYS



POLARISED TYPE

relays are of the balanced armature type. Sometimes the armature is balanced on a knife edge, sometimes it is pivoted as in the relay on the Ivy receiver shown in Plate VII. In every case it will be noted that there is provision for adjustment to the return spring.

Relay Adjustment

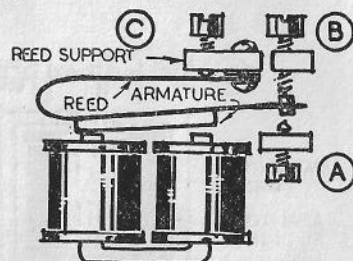
There are three variables which govern the adjustment of a sensitive relay, they are:

1. The gap between the armature and the pole piece of the magnet.
2. The tension on the armature return spring.
3. The gap between the contact points.

Assuming we have a relay that is completely out of adjustment let us start from scratch and give in sequence the correct method of setting the relay at the desired operating values.

Firstly study figure 1 which shows two well-known commercial relays in diagrammatic form. Contact "B" must first be screwed down so as to adjust the *magnetic gap* between armature and pole piece to approximately 3 thousandths of an inch. A feeler gauge should be used if possible, failing this, a piece of ordinary writing paper is near the correct thickness. Slip the gauge between the armature and the pole and screw down "B" until it just grips the feeler but not

FIG. 3.—A good space saving modification to the Siemens Relay is obtained by bending the reed back on itself.



METHOD OF MODIFYING SIEMENS TYPE BY BENDING REED BACK ON ITSELF

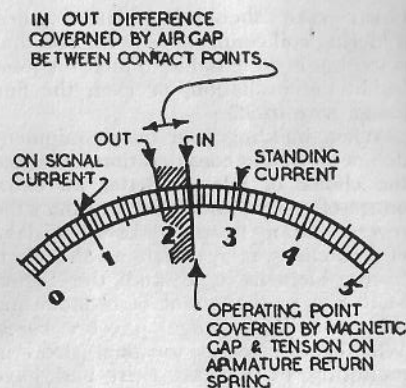


FIG. 2

so tightly that the feeler gauge cannot be slipped out. It is most important that contact "B" is not screwed so far in that the armature actually touches the pole piece as this will cause the armature to stick owing to the residual magnetism in the pole.

Now switch on the receiver with the potentiometer first set to zero, and then slowly raise the current watching the meter carefully and noting the point at which the relay clicks IN. To clarify matters we will assume that the required IN current is 2.4mA and the OUT current 2.0mA. If the relay does not come IN until the current reads say 2.8mA then we must screw in the adjusting screw "C" between an eighth to a quarter of a turn, remembering to switch off the set before we do so. It is a safe and wise policy to switch off before each adjustment to the relay, just in case our screwdriver should happen to short the high tension that runs through the relay coils. It will be appreciated that screwing in "C" decreases the tension on the armature return spring. If the relay still clicks IN a little too high then repeat the process a fraction at a time until the desired current reading of 2.4mA is obtained.

We must now set the *air gap* between the contact points by adjustment to contact "A". With the potentiometer again at zero—switch on and slowly

raise current until the relay clicks IN at 2.4mA, then gradually reduce and note the figure at which it drops OUT. In all probability it will be much less than our desired 2mA., so screw in contact "A" a fraction of a turn and repeat the check. The amount of movement at the points should be not more than a thousandths of an inch. If you now find that it is impossible to reach the desired CLICK IN to DROP OUT figures required then the armature is too

close to the pole piece. In other words, the *magnetic gap* is too small. Contact "B" must therefore be unscrewed and the whole of the above procedure gone through again until the desired settings are obtained.

Remember it is the setting of the *magnetic gap* in relation to the armature return spring that governs the operating point of the relay, and the *air gap* between the contact points that governs the IN-OUT ratio of the relay (Fig. 2).

BRITISH COMMERCIAL RELAYS

Type and Description	Manufacturer	Weight in ozs.	Size inches	Coil Resistance ohms.
Avionic — Balanced armature type with sensitivity of .4 m/A.	Amco Model Engines Ltd.	1	1 1/4 x 1 1/2 x 3/8	6,000-7,000
E.C.C. 5A—Spring tensioned armature with grub screw adjustment.	E.C.C. (Telecommander Ltd.)	1/2	1 x 1 1/4 x 3/8	3,500-5,000
E.C.C. P100—Polarised with grub screw adjustment. Contained in a black plastic sealed case. Connections made via a 6-pin plug and socket. Polarity can be reversed by reversing relay in relation to socket. Sensitivity .2 m/A.	E.C.C. (Telecommander Ltd.)	1	1 1/8 x 1 1/2 x 3/8	3,500
E.D. Mk. 111—Balanced armature with grub screw adjustment.	Electronic Developments (Surrey) Ltd.	3/8	1 x 1/2 x 1	5,000
E.D. Polarised — Polarised balanced armature, capable of operating at .5m/A.	Electronic Developments (Surrey) Ltd.	3/8	1 x 1/2 x 1	3,500
Manning-Carr P53 — Polarised with terminal connections which also serve as mounting bolts. Sensitivity of .25 m/A.	L. E. Simmonds Ltd.	1	1 1/2 x 3/4 x 3/8	Up to 7,000
Siemens Type 73 — Reed armature type with adjustment via knurled screw. Has twin coils usually of low resistance which are best replaced with similar coils of 1700 ohms each.	Only available as a surplus item.	2	3 x 1 1/2 x 3/8	3,400
Sigma SCR 522—Balanced armature, adjustment by grub screw on return spring.	Only available as a surplus item.	2 1/2	1 3/4 x 1 1/2 x 1 1/4	5,000

Chapter Five

Actuators and Control Gear

THE Actuator provides the mechanical energy that moves our control surfaces. It is usually a mechanical device activated by a solenoid, and driven by either a rubber motor, or in some cases an electric motor. The coil or solenoid, which operates in the main from 4½ volt batteries, is connected to one of the relay points and the relay earth. As previously explained, the opening and closing of the relay points, switches "On" and "Off" the actuator circuit.

Study Fig. 1B, which shows the actuator connected by a typical control linkage to the rudder. It will be noticed that the actuator consists of an aluminium or paxolin panel, drilled to take a shaft, on which is fixed a two arm pawl. When the pawl is in either of its vertical positions the rudder is correspondingly at neutral.

The escapement claw nearest to the pole piece of the coil acts as an armature, and is held away from the pole piece by a light spring tensioned around the shaft on which the escapement is pivoted. As soon as the coil is energised the claw is pulled towards the pole releasing the pawl, which, driven by the rubber motor, rotates through 90 degrees until it meets the other end of the escapement claw.

The rudder is now in the "LEFT" position and remains there as long as the relay points are closed. When the relay points are opened again the pawl rotates through another 90 degrees, bringing the rudder to "NEUTRAL" once more. A further signal and the procedure is repeated, giving us the "RIGHT" rudder position.

It will be appreciated that a pawl of four arms instead of two, can be used, giving fixed "LEFT" and "RIGHT" positions that remain after the signal has been released, and there are actuators that operate on this principle. The "self-neutralising" actuator as de-

scribed above, is, however, a much better and safer proposition for the tyro. Should his ambitions overrun his flying skill, then he has only to release the keying switch and the rudder automatically returns to neutral. Another scheme used, is to employ an extra pawl in one of the two neutral positions, and to use this as a wiper contact operating a separate circuit for two speed engine control. This does, however, make flying a little more complicated, and anything that complicates is definitely "out" for the time being.

There are several important points to watch relating to both the actuator and accompanying rudder linkages.

As with our relay, a certain amount of residual magnetism remains in the core of the coil. Enough in fact, to cause the escapement claw to stick, in spite of the return spring. For this reason, the pole piece or magnetic core, is usually given a thin coat of shellac to prevent the two metal surfaces actually touching. Do not therefore, scrape this coating off, thinking the metal has become tarnished or rusty, otherwise you may well regret it.

It is absolutely essential that our actuator mechanism is completely free from friction. The shaft should be dead straight, and light machine oil should be applied sparingly to the bearings, also the pivot point of the escapement claw. Avoid, however, at all costs, oil on the claw itself, as the last thing we want is for the pawl to slip off the claw. Make certain that the rubber motor is not out of line with the shaft, i.e., riding up the hook on the end of the shaft, as this can cause binding, and in turn a stuck on rudder.

It will be appreciated that the ends of the pawl are shaped as they are for a purpose. The face meeting the claw under *working* rotation is flat, and the face meeting the claw under *winding*

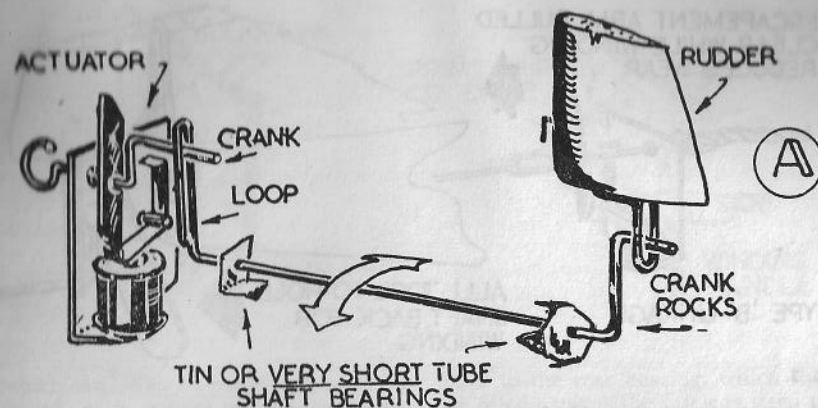
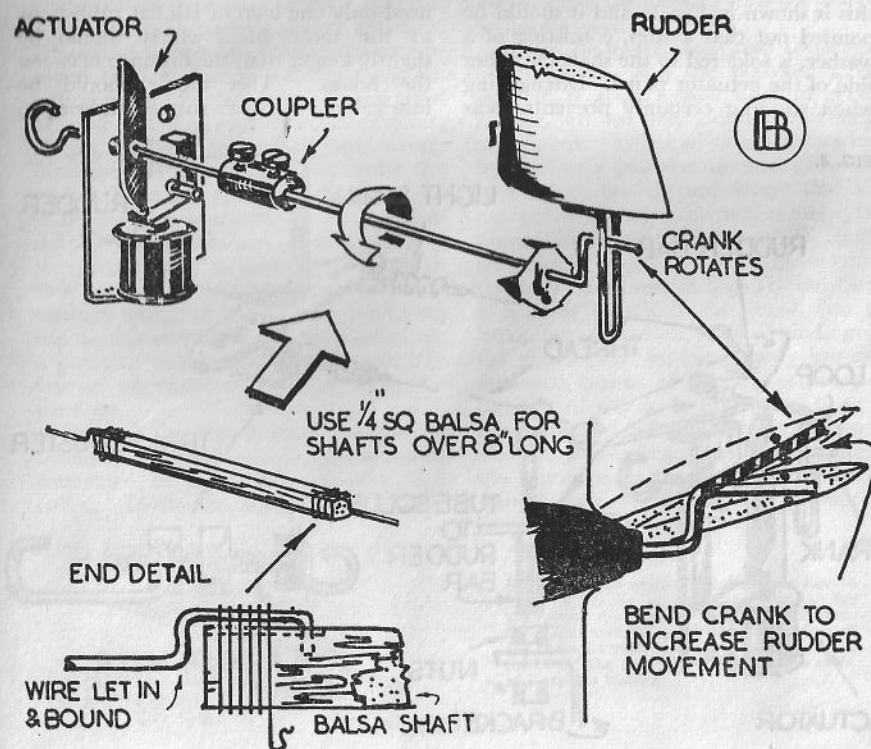


FIG. 1.—The "Rocking crank" system of rudder linkage shown in 1A above is usefully employed in keeping the crank rod well clear of the tailplane when the latter is mounted on the fuselage. Where a low mounted tailplane is used the system is easily modified by inverting the crank and if necessary the actuator itself. In point of fact it is safer to position the actuator so that the armature claw is held away from the core of the solenoid by gravity, i.e., the reverse of the illustrations shown on this page.



ESCAPEMENT ARM PULLED
CLEAR WHILE WINDING
REDUCES WEAR

TYPE 'B' LINKAGE

ALLI. TOOL TO HOLD
SHAFT BACK FOR
WINDING

FIG. 2.

rotation is bevelled. Although commercial actuators are made this way for winding purposes, the author does recommend that the shaft is withdrawn from the rear, sufficient to free the pawl from the claw. A method of doing this is shown in Fig. 2, and it should be pointed out that a stop, consisting of a washer, is soldered to the shaft the other side of the actuator panel. Disengaging when winding certainly prevents wear

of both the pawl and the claws, so avoiding the possibility of a skipping escapement.

Correct choice of rubber motor is another important point that makes for successful operation. Most actuators need only one loop of $\frac{1}{8}$ th flat rubber, or at the most $\frac{3}{8}$ ths, which should be slightly longer than the distance between the hooks. This motor should be lubricated with a rubber lubricant,

FIG. 3.

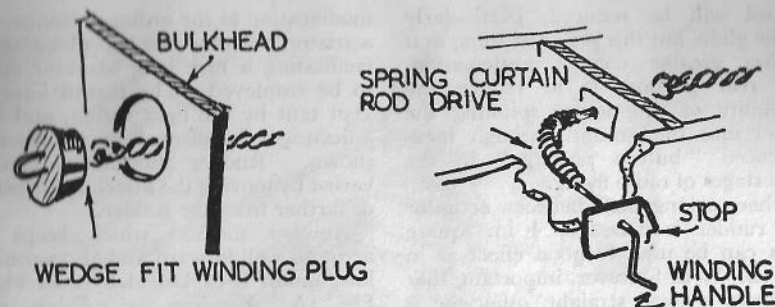
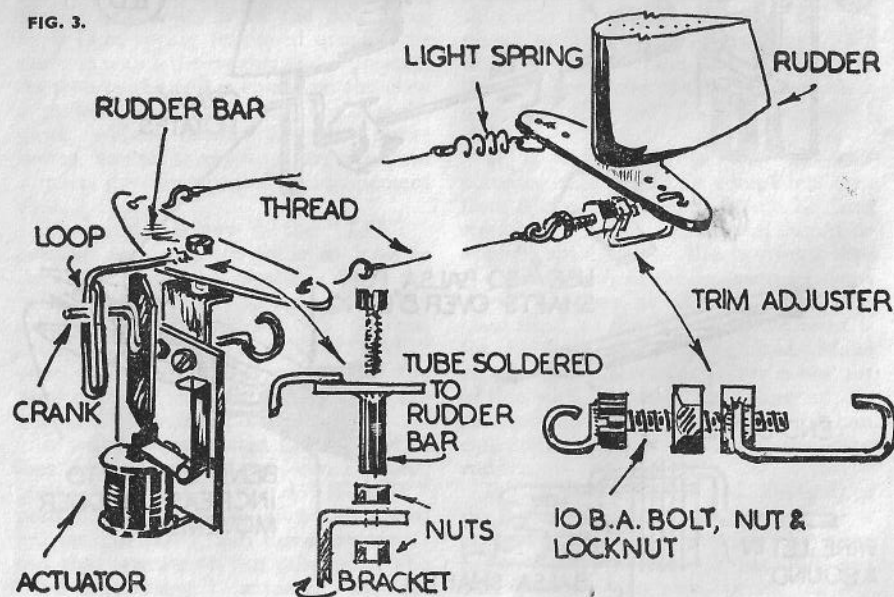


FIG. 4.

which can either be made from soft soap mixed with castor oil, or purchased commercially. It should be replaced at regular intervals, as unlike the rubber motor used for flying Wakefield models, it is invariably left in a wound condition. You should always carry a couple of spare made-up motors in your tool kit.

On the E.D. current saving actuator, which the author can thoroughly recommend, there is a small leaf wiper contact which meets the inner face of the pawl at one point of its rotation. It is possible, if the shaft is turned in the wrong direction, for the pawl to run under the end of this contact, which being made of shim brass, is likely to get bent out of shape. This again can cause sticking of the actuator, or in some cases result in the wiper contact no longer making contact with the pawl, thus rendering the unit unserviceable. This is definitely a point to watch, and another point in favour of withdrawing the shaft for winding.

Fig. 1B is the normal method of linkage, and shows an E.D. type actuator connected to a crank by means of a collet. Particular attention should be

paid to the rear bearing, which should be fitted around the fuselage stern post. It is safer to make these bearings from small pieces of tinplate drilled to take the crankshaft. They can be made from tubing, but the tubing should be short, and great care should be taken to ensure that the bearing lines up with the shaft so as not to bind.

It will be appreciated that the length of the crank, and the position of the yoke in relation to the fulcrum of the rudder, govern the amount of rudder movement. Either of these factors can be used to adjust the amount of rudder movement, but do not forget that the nearer the yoke is to the rudder hinge, the more effort is required to move it. Slight adjustment can be obtained by bending the crank as shown in Fig. 1B, but there is a limit to which the crank can be bent, beyond which causes binding in the yoke. The author usually has two or three cranks of the correct length, but varied depth in his model box, to accommodate different flying techniques. For first flights beginners should restrict the size of their crank to give no more than $\frac{1}{8}$ in. movement. The amount of

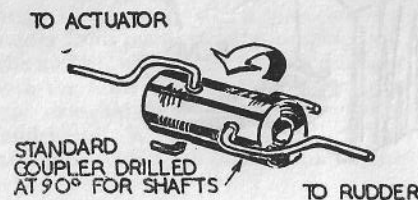


FIG. 5.—Most commercial actuators feature either a Paxolin or aluminium coupler for connecting the actuator to the rudder shaft. By drilling two holes at right angles through the coupler a useful universal joint is obtained that will take up any side play on the shaft, and prevent binding.

control will be reduced, particularly on the glide, but this is a good thing as it teaches greater control anticipation. The real purpose is to reduce the possibility of the novice spinning the model into the ground through inexperienced "button pushing" in the early stages of radio flying.

Where a long shaft between actuator and rudder is necessary $\frac{1}{4}$ in. square balsa can be used to good effect as in Fig. 1B. It is, however, important that the balsa is dead straight, otherwise it will induce side loads on the actuator shaft and cause binding.

An alternative scheme which enables the actuator to be placed nearer to the radio compartment, is shown in Fig. 3. As can be seen, this only needs slight

modification to the ordinary commercial actuator, and has one big advantage in facilitating a nice long actuator motor to be employed. The thread lines are kept taut by the light spring, and trim adjustment is effected in the manner shown. Rudder movements can be varied by moving the attachments nearer or farther from the rudder.

Another method which keeps the actuator well forward and also permits a long motor is explained by reference to Fig. 1A. Keeping the rocking crank idea we invert the actuator and bring it the other side of the loop so that the shaft faces forwards with the loop in front of it. The motor hook then faces to the rear.

With some control schemes it is not

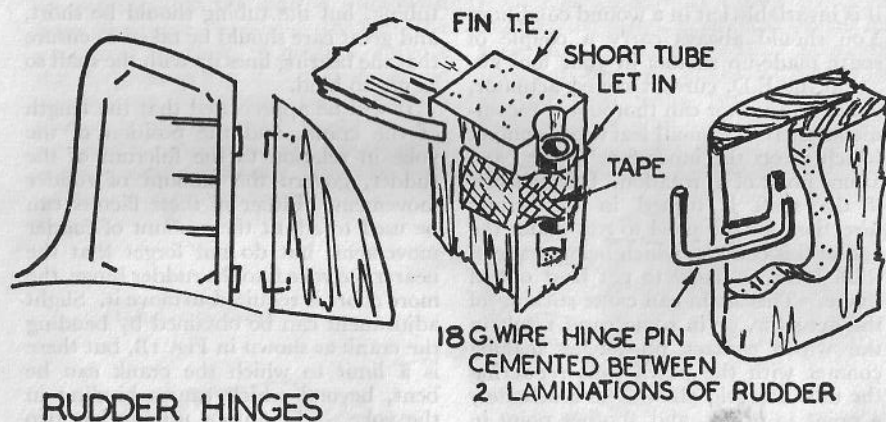


FIG. 6.

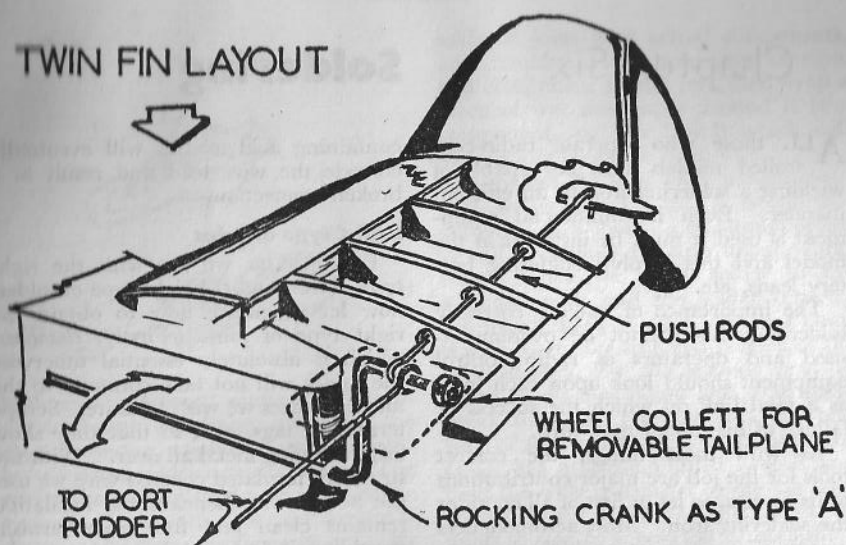
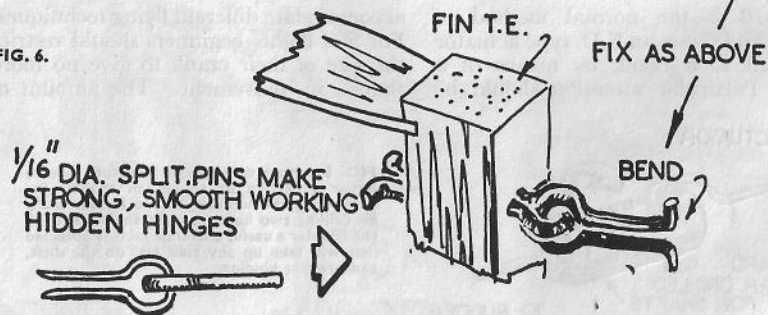


FIG. 7.—This system of twin fin linkage has internal control rods and great care should be taken to ensure complete freedom of movement. With a more forward mounted tailplane the connecting rods can be run externally, positioned aft of the tailplane trailing edge.

practical to wind the rubber motor from the rear, and two methods of facilitating winding from the radio compartment are shown in Fig. 4. With the tapered plug, one uses a normal twist drill winder for applying turns.

Progressing from the linkage to the rudder itself—the same close attention to friction free movement must be maintained. Quite a number of people use linen hinges similar to those employed on control line models. They are not, however, a permanent proposition, and never give quite the same free movement as a proper hinge.

Hinges similar in principle to farm gate varieties are very satisfactory, as shown in Fig. 6. Note that the lower hinge is reversed, which prevents the rudder from inadvertently jumping out. The author, who at one time used hinges both the same way, so that the rudder was detachable, actually knocked the rudder off a "RudderBug" when launching with a full tank. Some say he

has been permanently unhinged ever since! Be that as it may, the subsequent cross country run has been a permanent reminder of the necessity of installing rudders that stay put!

Fig. 6 shows another satisfactory method of fabricating hinges from split pins, which is self-explanatory.

The ordinary radio control model with a single fin in the slipstream of the propeller is more responsive to rudder movement when under power than it is on the glide. For this reason many people use twin fins on the end of the tailplane, which places the fins well clear of the slipstream, thus giving the same measure of control both "power on" and "power off". A suitable system of control linkage is shown in Fig. 7, and again it is emphasised how important it is that all cranks and bearings are completely free in movement.

The installation of actuators is dealt with in Chapter XII.

Chapter Six

Soldering

ALL those who operate radio-controlled models must be capable of wielding a soldering iron in an efficient manner. Even if commercial equipment is used it must be installed in the model and this involves soldering battery leads, etc.

The importance of making correctly soldered joints cannot be overemphasised and operators of radio control equipment should look upon each joint as a vital link on which the success or failure of his model may turn.

As with most things, the correct tools for the job are major contributions to its success, so let us first of all consider the soldering iron. Most aeromodellers possess a medium iron which they use for the normal modelling jobs such as undercarriages, prop shafts, etc. For actual receiver construction this type of iron is too large but can be used for wiring installation providing care is taken at the receiver joints. Obviously, if excessive heat is applied to delicate components it will not do them much good. On the other hand, one of the main essentials necessary for a good soldered joint is that the joint should be really hot. Hot enough that is for the solder to run freely when applied to the joint.

The ideal iron for electrical work of our nature has a round bit some quarter of an inch in diameter shaped at the end to a fine point (Fig. 1). It is possible to purchase dual-purpose electric irons with interchangeable bits which are ideal for modelling purposes and an excellent investment for the radio control enthusiast. Now for the solder itself, which again must be of the right type for our particular purpose. Cored solder is the ideal as it melts easily, and can be got into awkward corners without undue difficulty. Furthermore, it saves a hand by containing its own flux. On no account use an acid core flux or use Bakers' Fluid or any other type of flux

containing acid as this will eventually corrode the wire lead and result in a broken connection.

Right type of joint

Equipped as we are with the right type of iron and the right type of solder, now let us ensure how to obtain the right type of joint. Firstly, *cleanliness* which is absolutely essential otherwise the solder will not take correctly to the metal surfaces we wish to unite. Scrape terminals, tags, etc., so that they show bright shining metal all over. With the stranded, insulated covered wire we use, the actual wire beneath the insulation remains clean and free from tarnish, providing it is bared just prior to the joint being soldered. Do not, however, bare more of the wire than is necessary.

Now for stage two of the operation—tinning the iron. Allow time for the iron to reach its correct heat and then clean the point of the bit with a small file. Next apply the cored solder which should run over the surface of the bit on its own accord leaving a bright surface of solder. The iron is now "tinned" and ready for use. Stage three is to tin the actual surfaces to be joined. Most of our joints consist of a wire joined to a tag which do not take long to heat up, in fact, with the wire,

FIG. 1.

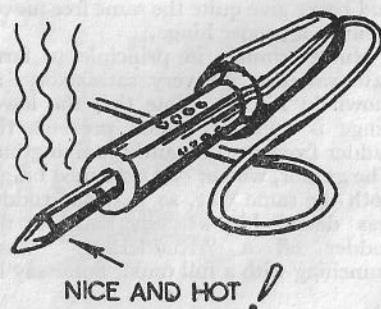
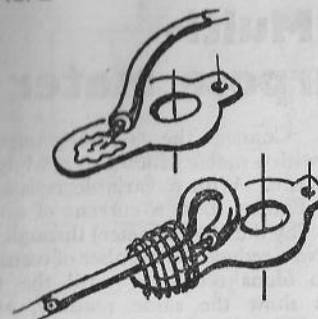


FIG. 2.



both iron and cored solder can be applied almost simultaneously. In the case of the tag, apply the iron followed by the cored solder a second later. The solder should run freely over the entire surface; if not, then either the surface is dirty or the iron insufficiently hot. By the way, do twist the bare wire tight before tinning it, as apart from spiky ends of wire looking untidy, they can sometimes short on adjacent terminals. It now only remains for the wire to be inserted through the tag, the iron applied, and the joint is complete. Again the solder should run freely over the entire joint and it should not be necessary to apply the iron for more than two or three seconds at the most. Great care must be taken when making a

soldered joint near actual components, and should you have your iron too close to a component for comfort, then wrap a piece of wet newspaper around it (the component—not the iron!) which will absorb any excessive heat.

Although we now have a nice clean and well-soldered joint, it is still not complete as a joint. Left unsupported, it will eventually fracture under vibration. When we apply solder to the stranded wire lead the solder runs up the wire a small distance. A weak point occurs where the stiffened portion of the wire finishes, for the strands tend to separate at this point and eventually break through. Fig. 2 shows the best way of supporting the joint, which first of all has a sleeve slipped over it and then the wire is secured to the tag with waxed thread as shown. *All, repeat all* joints should be supported in this fashion for 100 per cent reliability.

One final warning, never solder a joint with an iron that will barely run the solder as this, coupled with dirty connections, will almost certainly result in a dry joint. A dry joint can cause no end of trouble through building up resistance in the circuit. Outwardly, it looks innocent and will very often stand up to a pull test, but, inwardly, it has a rotten core and may well sound the death knell of your model.

Join the S.M.A.E.

(Society of Model Aeronautical Engineers Ltd.)

This is the governing body of aeromodelling, affiliated to the Royal Aero Club, and looks after the interest of aeromodellers throughout the British Isles. It runs special contests for Radio Control Model Aircraft and offers **Third Party Insurance** as a condition of membership. Associate Membership is only 3s. per annum.

Full particulars from The General Secretary, S.M.A.E. Ltd., 19 Park Lane, Piccadilly, London, W.1.

It is essential in your own interests that you are insured against Third Party Risks when flying a Radio Controlled Model Aircraft.

Chapter Eight

The 'Aeromodeller' Transmitter

BASED on the original circuit described by Howard Boys in the June, 1952 "Aeromodeller", this simple unit was designed and built by Ted Sills and the author in a matter of a few hours. All the components were purchased over the counter at a well-known model shop, including the neat and workmanlike case. All are standard, the only surplus items being the Air Ministry pattern 0 to 50 m/a moving coil meter and micro-switch, which are, in any event, in plentiful supply throughout the country.

It is emphasised that the prototype is a de luxe version incorporating many refinements that can be omitted if economy is necessary. This unit was, however, deliberately built de luxe, as the author feels that a transmitter is an instrument that should last a lifetime, and consequently worth spending a little time and money over. The B136 Batrymax which combines both H/T and L/T supplies for instance, costs a little more than ordinary batteries, but the plastic four-pin plug that goes with it is already made up complete with colour coded flex. It certainly makes a neat and efficient job, and being designed for portable radio use, is small in size, thus permitting the construction of a very compact unit.

For those who wish to economise the following suggestions are made: The case can be home built or obtained government surplus: the 0 to 50 m/a meter can be omitted, especially if the builder has an All Purpose Meter as described in Chapter VII. The leads that at present connect to the meter can then be terminated at a polarised two-pin socket, with a shorting plug for when the meter is not connected. A cheaper plastic "On-Off" switch can be used,

and the micro-switch replaced by a plastic push button switch. The valve screen can be omitted and the Keying choke can be home constructed by winding two separate layers of 28 turns each of 22 gauge enamelled wire on a $\frac{3}{8}$ inch paxolin tube 2 inches long. The tube should be drilled and slotted for attachment as per Fig. 3. The Mullard DCC 90 or American type 3A5 valves can sometimes be obtained ex-Government at around 10s. each and there is another surplus valve that can be used, the 3B7/1291. This valve does, however, require a slightly larger valve holder so the panel must be modified accordingly. It also has eight pins instead of seven No. 5 not being used.

We are, however, hoping that the reader, after studying the photographs in Plate IV, will be satisfied only with a first class job, and pass on to a detailed step-by-step description of the prototype. Pausing for a moment to mention that it was tested, using a standard E.C.C. 951A receiver, up to a range of one mile, at which distance the receiver was still giving maximum current drop. The receiver was only tuned once, this at close range, and no subsequent adjustments were found necessary.

The Case

The case involves a fair amount of drilling, so if you can borrow the use of a bench or power drill so much the better. Holes must be drilled to take the switch, the keying lead socket, the meter, and the aerial socket. Again, if you can borrow a press tool for the large holes, you will save time and effort. If not, then they must be cut the hard way by drilling all round the circumference with an $\frac{1}{8}$ drill, and finally snipped out with a pair of snips. Use the actual accessories as

figs for marking out their mounting holes, and be careful with the somewhat brittle plastic of the meter when tightening up the mounting screws. Do not drill mounting holes for transmitter unit at this stage.

The Tuning Coil

Find a $\frac{7}{8}$ inch diameter piece of dowel or tubing about a foot long, run a $\frac{1}{8}$ inch drill through one end at right angles. Take a 40 inch length of 18 gauge enamelled copper wire, thread it through the hole and take on a turn to get a grip. Secure the other end in a vice and pull hard to straighten the wire. Keeping a fair tension wind on 12 tight evenly spaced turns, which will slip easily off the former when completed. You now have a neat coil containing more turns than are actually required, which must be cut down to eight full turns, leaving an additional $\frac{3}{8}$ inches of wire at each end, bent as shown for mounting. These ends must be scraped clean of enamel for soldering, also a small section in the exact centre for the centre tap. Take a short length of the same

wire and remove the enamel. Form a small loop and solder this to the centre tap as per Figure 3. The aerial coil is now ready for fitting in the appropriate sequence as given in the wiring instructions.

The Transmitter Unit

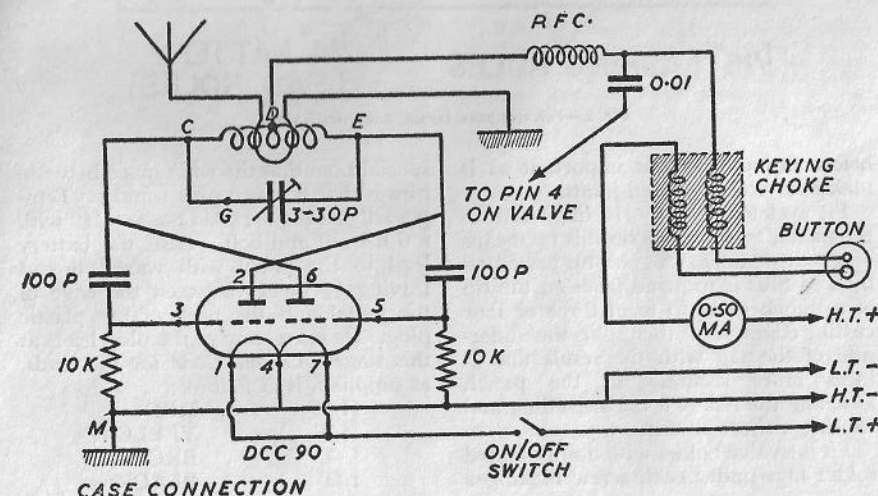
The Panel is cut from $\frac{1}{8}$ paxolin sheet which is marked out on the underside by means of a scribe, as per Fig. 2.

Firstly, make the hole for the valve holder by drilling round the circumference of the $\frac{3}{8}$ inch scribed circle with a $\frac{1}{8}$ inch drill. Keep slightly to the inside of your guide line, and drill the holes as close together as possible. Using a balsa knife, cut through the divisions between the holes, working from both sides of the panel to avoid splitting the paxolin. Finish off the hole with a round file, followed by emery paper round the file or a piece of dowelling.

Drill the remainder of the panel holes exactly as per Fig. 2 with a $\frac{1}{8}$ inch drill, using a pilot drill first so as to obtain clean holes.

Scrape all tags and component connections until you have bright metal

Fig. 1.—Circuit diagram shows one additional component not mentioned in the wiring instructions—a .01 condenser connected between Tag J and pin 4 of valve, i.e. between the transmitter side of the keying choke and the common negative. This is to ensure that there is no circulating R.F. current in the keying lead as the internal impedance of the battery rises with age.



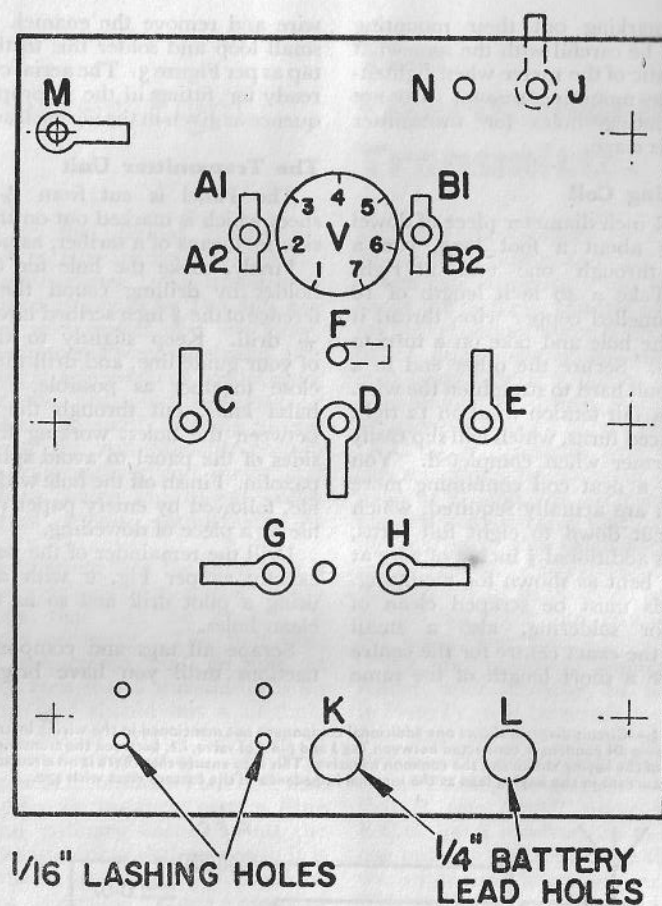


Fig. 2.—Full size panel layout, underneath view.

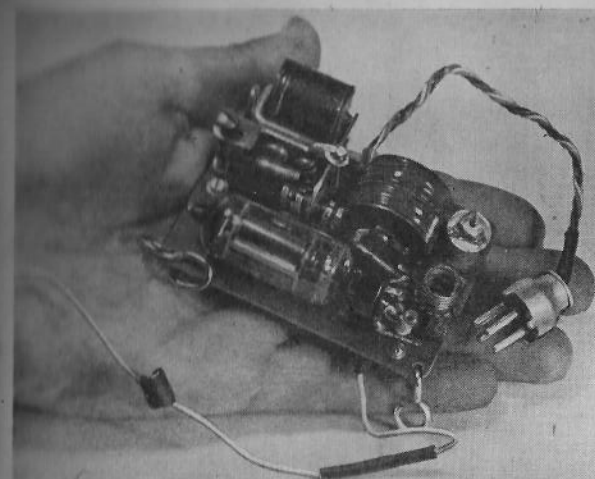
before fitting. This is important as it makes for good soldered joints.

Fit eyeleted tags by riveting them to the panel, most people do this by means of a centre punch. A good tip passed on by Ted Sills is to grind faces on the tip of a punch so as to form three or four cutting edges. This then splits the underside of the tag with the result that it locks more securely to the panel, lessening the risk of a tag swivelling and causing a short circuit.

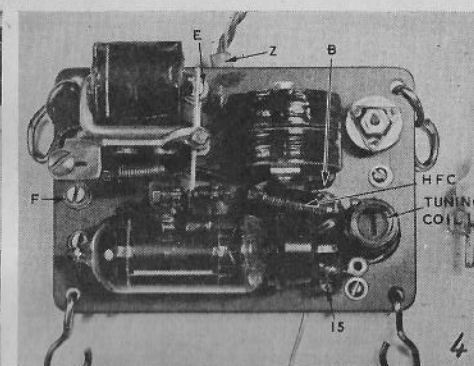
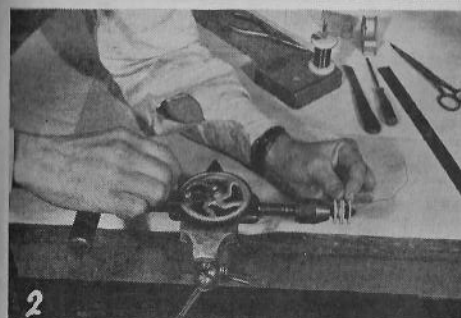
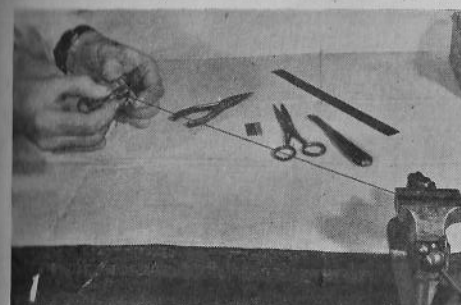
Fit the valve holder with double ended solder tags under each screw making a

special note that the wide space between pins is that between pins 1 and 7. Temporarily fix single ended tag to "M" with a 6 BA nut and bolt. Lash the battery lead to the panel with waxed thread leaving $3\frac{1}{2}$ inches between the edge of the panel and the neck of the plastic plug. Do not cut any of the plug leads at this stage. Colour Code for the leads, as supplied, is as follows:

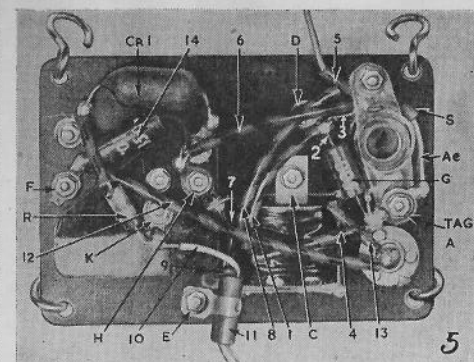
H/T	+	RED
H/T	—	YELLOW
L/T	+	BROWN
L/T	—	BLACK

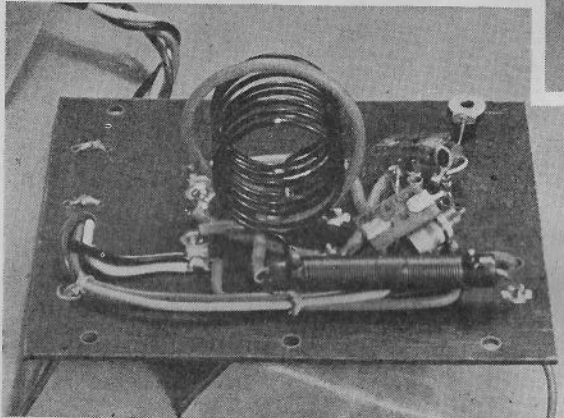
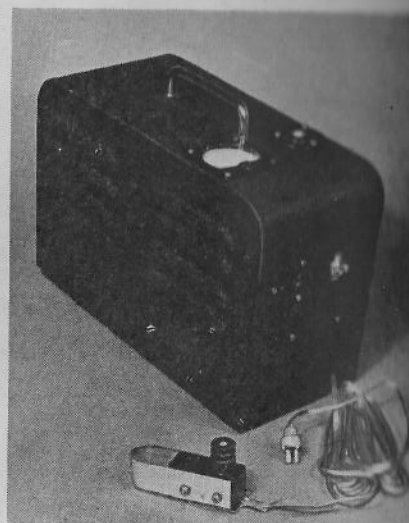
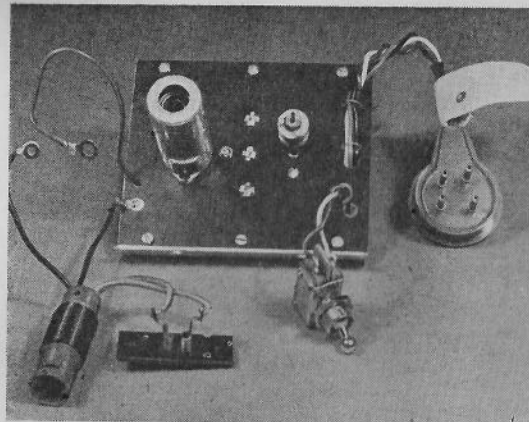


An example of the "Aeromodeller" Receiver built by Sid Miller of Luton. This version is equipped with the SCR 522 relay, and home-made quench coils wound in the manner described in Chapter IX. Photo 1, shows the method of winding the tuning coil which consists of 15 turns of plastic covered flexible wire on an Aladdin former. Photo 2, demonstrates the method of winding the quench coils, which have 750 turns of 38G wire on each section of the bobbin; easily done by means of a hand drill locked in the vice. Photo 3, is a close-up of the drill chuck with the bobbin partly wound. Note the threaded 2BA rod which



holds the two bobbins firmly in position whilst winding, and the free end of the thicker connecting wire from the inside, which is held to the outside of the bobbin with Sellotape when winding. The very useful attachment hooks are links from the chain that hangs in the "little room"!





Pictures above, and left, show various views of the "Aeromodeller" Transmitter. Note the neat four pin battery plug, which is obtainable commercially complete with flex. Also the keying lead with micro-switch modified as detailed in Chapter II. Chassis is attached to the case by means of simple dural or aluminium brackets with 6BA nuts and bolts.

Below, is Mr. Bayer's Multi-Purpose Meter, which is neatly finished in black cellulose. Full details of this invaluable instrument are given in Chapter VII.

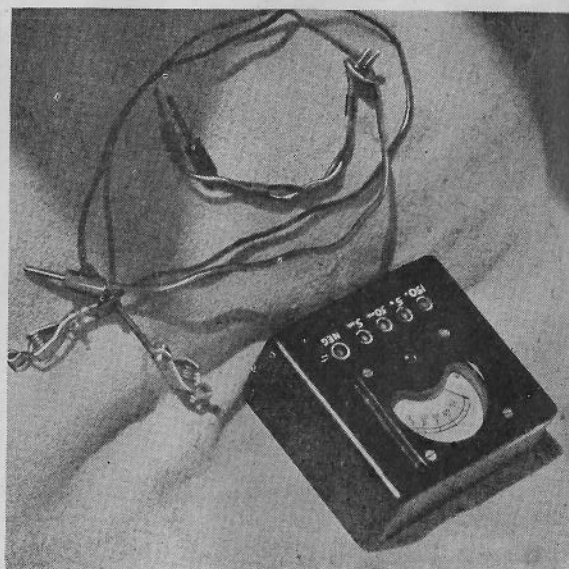
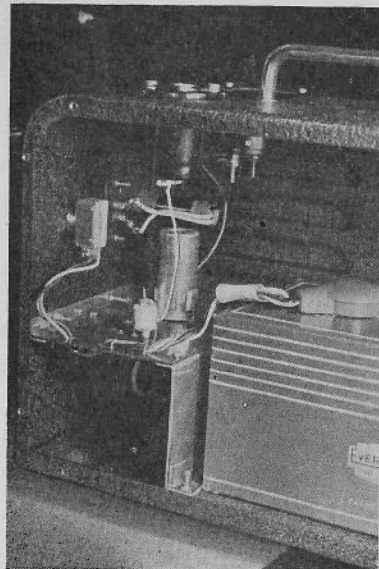
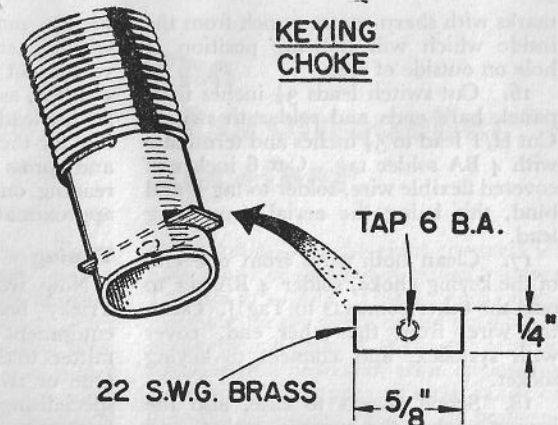


PLATE IV

Fig. 3.—Keying Choke is made from a 2 inch length of $\frac{1}{8}$ " paxolin tube drilled and slotted as shown. Two separate windings each of 28 turns of 22 gauge enamelled wire are wound one on top of the other, the four ends are passed through the drill holes and taken out through the inside of the paxolin tube.

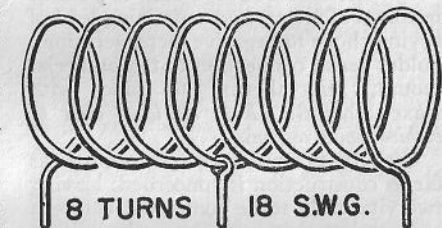


Wiring Connections

Fig. 2 shows the underneath of the panel with all the various tags keyed for easy reference. If you follow the sequence exactly as given, then no difficulty should be experienced.

1. Connect *M* to *A1* to pin 4 of valve.
2. Connect *B1* to *H*.
3. Connect *Black* and *Yellow* battery leads to *H*.
4. Connect 10k resistors in turn, one from *A2* to pin 3, one from *B2* to pin 5.
5. Fit 30 pf Beehive on the top of the panel by soldering centre pin through tag *G*. Trim off surplus pin.
6. Connect pin 2 to tag *E* continuing connection to side contact of beehive. Do not solder to tag *E* at this stage.
7. Connect pin 6 to tag *C*, continuing lead to tag *G*, again not soldering to tag *G* at this stage.
8. Connect one 100 pf capacitor between pin 3 and tag *C*, and the other between pin 5 and tag *E*.
9. Thread *Brown* battery lead through hole *L* and twist with it a similar length of flexible lead, sufficient to run from the switch to the valve holder. Connect this switch lead to pins 1 and 7, stripping enough covering to run wire from 1 to 7.
10. Thread *RED* battery lead through hole *N*, running it alongside the switch lead, and tying it with waxed thread to this lead, and the lead already joining *B1* and *H*.
11. Bend one lead of R.F. Choke at

AERIAL COIL



right angles, remembering to scrape ends of both choke leads before soldering. Connect right angled lead to tag *D*, the other end to tag *J*. Cut off excess wire after soldering.

12. Cut $5\frac{1}{2}$ inches of 18 S.W.G. wire, scrape bare $\frac{1}{8}$ inches at each end, and insulate with systoflex. Insert one end into centre hole of tag *H*, passing wire under R.F Choke connection. Form into single loop and solder other end into centre hole of tag *F*. Ensure that link coil straddles centre tag *D*.

13. Thread coil carefully through the link coil and solder coil connections to tags *C*, *D* and *E*.

14. Cut the two mounting brackets to shape. Bend in vice and drill 6 BA holes as per Fig. 2.

15. Bolt brackets to Tx panel, and offer the Tx chassis complete to the case. Mark position of fixing holes on the inside, using the brackets as a jig. Pip

marks with sharp centre punch from the inside which will indicate position of hole on outside of case.

16. Cut switch leads $3\frac{1}{2}$ inches from panel, bare ends and solder to switch. Cut H/T lead to $5\frac{1}{2}$ inches and terminate with 4 BA solder tag. Cut 6 inches of covered flexible wire, solder to tag F and bind, this being the aerial connecting lead.

17. Clean both wires from one end of the keying choke, solder 4 BA tag to one, the other connects to Tag J. Clean the wires from the other end, cover with systoflex, and connect to keying socket.

18. Screw chassis to case, also the keying choke, the two-pin socket, and the "on-off" switch.

19. Connect red H/T lead to positive terminal of meter, and remaining lead of keying choke to negative meter terminal. Solder aerial connection to tag on aerial mount, remembering to bind with waxed thread. *Keep all leads clear of beehive tuning condenser.*

Well, that completes our transmitter as far as construction is concerned, leaving two vital tasks to be completed before it can radiate energy into the ether.

Firstly, make a thorough check of all wiring, keeping in mind the fact that valves cost 29s. 6d. per time! If you are satisfied, assemble the aerial, plug in the keying lead, switch on, allow a second or two for the valve filaments to warm up, and press the keying switch. The reading on your milliammeter should be approximately 27 m/a with full aerial.

Tuning

Now we come to the tricky part. Tricky because few people have the equipment for accurately tuning transmitters to the specified G.P.O. frequency. One or two of the larger model shops specialising in radio control do offer frequency checking services, and the author will be pleased to put readers in touch with their nearest frequency checking service on receipt of a stamped addressed envelope. People who are not in a position to take their transmitters for tuning, and who must send them by post, should make certain that they are very securely packed. They should be well insulated against bumps en route and enclosed in a stout carton. Do not forget to enclose the necessary amount for return postage in addition to the fee.

'AEROMODELLER' TRANSMITTER

PARTS LIST

Case

- 4 $\frac{1}{2}$ by 4 in. of 18 gauge Aluminium Sheet.
- 3 $\frac{1}{2}$ by 4 in. of $\frac{1}{16}$ Paxolin.
- 1 "On-off" Switch.
- 1 Polarised 2-pin plug and socket.
- 1 Keying Choke.
- 1 Aerial Socket.
- 1 0-50 m/a Moving Coil Meter.
- 1 8 ft. Sectional Aerial.
- 1 Ever-Ready B. 136 Batrymax 90v.
- 1 Every-Ready Plastic 4-pin plug and lead.
- 17 6 BA nuts and bolts.
- 3 4 BA nuts and bolts.

- 1 $\frac{1}{2}$ ft. Systoflex.
- 1 ft. Plastic covered multi-strand wire.
- 3 $\frac{1}{2}$ ft. 18 gauge enamelled copper wire.
- 1 ft. 20 gauge tinned copper wire.
- 1 D.C.C. 90 valve.
- 1 Valve screen.
- 1 B7G valve holder.
- 1 30 pf Beehive condenser.
- 2 10k Resistors.
- 2 100 pf \pm 1 per cent Condensers.
- 1 Eddystone 1011 R.F. Choke.
- 8 Single-ended riveting tags.
- 2 Double-ended solder tags.
- 1 Micro-switch and lead.
- 1 Condenser .01

Chapter Nine The 'Aeromodeller' Receiver

DESIGNED originally by Doug. Bolton the Aeromodeller No. 1 Receiver was first described by Howard Boys in the October, 1952 issue. Since that date many hundreds have been built, and there is no doubt that it is a very sound and easy to build unit. One of the best interpretations was described by Sid Miller in the May and June, 1954 issues of *Aeromodeller*, and as Sid's step by step instructions make building almost child's play the author proposes to quote them ad. lib.

This is a first class unit, never having let us down, despite very rough usage. It has proved stable, quite easy to adjust, will stay set and is very economical on batteries. The range is all that could be desired, being far greater than sight, with a five foot model. As described, it weighs $5\frac{1}{4}$ ozs. with a $2\frac{1}{2}$ oz. Sigma SCR 522 Relay, Aerial, battery leads, and four pin plug. Weight could be reduced and wiring simplified by a different lay-out, but experience has proved that shown to be the best. Field servicing, get-at-ability and ease of construction have been fully considered.

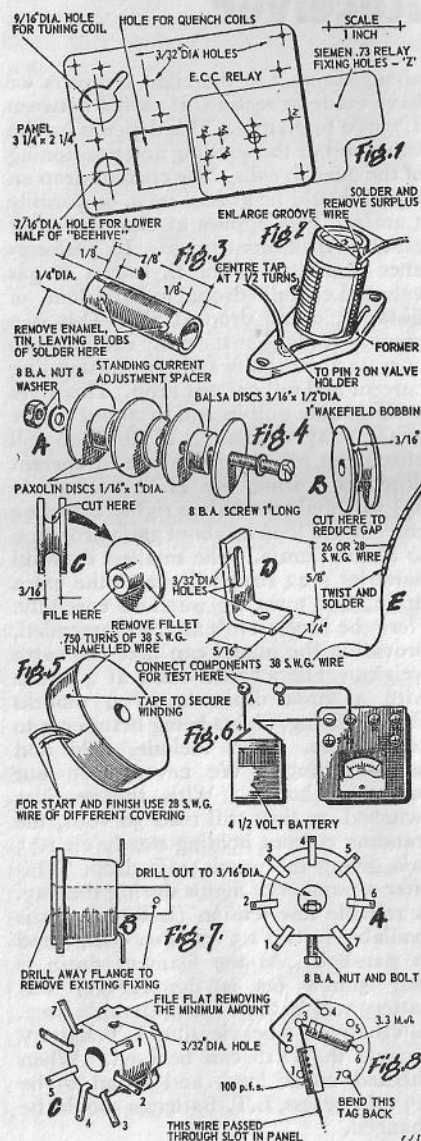
If, on a dicey landing, one is in doubt about possible damage to components or wiring, it can soon be spotted and put right. *We strongly advise against any alteration to the lay-out whatever.* Before we proceed any further, a word or two on the relay. The Sigma SCR 522 5,000 ohms coil resistance type, although heavy ($2\frac{1}{2}$ ozs.), is a marvellous job and really priceless, especially on this type of receiver. *The weight means nothing compared to reliability, for once adjusted it will stay set for months!*

To return to the receiver. With batteries as recommended, i.e. H.T. 45 vs, the standing current should be

about 2m/a. On the eight receivers we have made or rectified it varied between 1.75m/a to 2.2m/a. This depends on the valve and/or the winding and positioning of the quench coils. The current drop on signal should be at least 1m/a. or possibly 1.2m/a. This applies at close range or absolute maximum range. Its performance is similar to the thyatron or gas valve, i.e. full drop, independent of distance, or no drop at all. This is a great advantage as the relay can be set to operate about halfway between standing current and full current drop. This gives a reasonable pull in and drop out power to the relay armature. If vibration still affects the relay, an increase in current drop by raising the H.T. voltage to 67 $\frac{1}{2}$ vs. should put things right. Standing current will then be about 3m/a dropping to about 1.2m/a. The smallest deaf-aid batteries (122 size) will stand the extra drain, but must be watched carefully. Here the larger 110's are recommended, providing the model can take the extra weight. The smaller 122's at 45 volts with a 2m/a drain lasted 9 months average flying, flights being between 5 to 10 minutes. This includes field and bench testing. We never swap our batteries about! With the receiver switched on they still read 36 volts, the standing current holding steady on 1.75 m/a giving the usual 1m/a drop. This after a number of flights during the day. A reliable low tension (L.T.) supply is available in two 1.5 volt Pen cells, wired in parallel. As the filament drain is only 50m/a (as is the XFG1) this battery will last some considerable time. Alternatively a heavier duty L.T. Battery such as the D.18 can be used. When checked under load, and found to be 1.3 volts or less, L.T. Batteries should be changed.

The Panel. (Fig. 1)

This is made from $\frac{1}{8}$ in. Paxolin sheet, which is obtainable from any radio dealer. Paxolin is rather brittle, but can be cut with a fretsaw, using a



medium cut blade. Cut to size as shown in Fig. 1, afterwards making a tracing of Fig. 1 fixing to the Paxoline with Sellotape. Centre punch holes where marked. Use moderate pressure when drilling or badly chipped holes will result. Remove all burrs from both sides of the panel. The dotted line in Fig. 1 represents the Siemens 73 relay, which should be mounted, complete with its own paxolin base on top of the panel (see assembly instructions). All holes should be drilled $\frac{3}{32}$ in. dia. except the four corner ones, which are $\frac{1}{8}$ in. dia. Fretsaw out the tuning coil hole, not forgetting the projecting slot, the Beehive Condenser hole (a trifle undersize), and also the square for the quench coils. As very few Sigma relays are obtainable, no holes are shown as the position varies with each one. The E.C.C. relay will fit comfortably being very simple to fix. Drill to suit relay.

The Tuning Coil. (Fig. 2)

Take an Aladdin former, which should be of the transparent type, which has four fine grooves spaced round the circumference. One of these should be made deeper and wider using a small file or penknife point. This should be made deep enough to hold in position a short length of 20G. or 22G. tinned copper wire. If your particular former is plain, a groove must be made the full length of the former, conveniently near the wire fixing holes. When working on the former it is advisable to keep the slug inside, thus allowing the former to be handled without splitting. The same wire is also used to wire up the receiver where required and about 1 yard will do, being obtained from Woolworths as plastic covered single cored, the covering being removed. Taking about 4 in. feed through the two holes (Fig. 2) leaving about $1\frac{1}{2}$ in. for connection to valve holder. Bend and form into groove as shown. Take about 24 in. of the flexible, covered wire (that to be used for battery leads), thread this into the other holes leaving about $1\frac{1}{2}$ in. spare. The other end of the wire should be secured to the bench or vice. Stretch-

ing the wire taut, wind on $7\frac{1}{2}$ turns by turning the former, working towards the bench. (Photo 1.) Making sure the length of tinned wire is in its groove, wind over it. It will then be held firmly in position. At $7\frac{1}{2}$ turns, and still keeping the wire stretched, cut round the covering with a razor blade—being careful not to cut into the fine strands of wire. Pull back the covering until about $\frac{1}{4}$ in. of bare wire is exposed. Double back and twist into a loop. Continue by winding on another $7\frac{1}{2}$ turns. As the 15th turn crosses the bare wire, note the spot and again cut through the insulation. Pull back the covering and, bending the stiff wire outward (Fig. 2) twist the bare part round it close to the former, making sure the coil winding is tight, apply flux and solder. Cut away surplus wire. Twist centre tap tight and tin. The length of the completed winding should be approximately $\frac{3}{4}$ in. which is the length of the slug. This means that the plastic covering must be very thin. If other wire is used, i.e. enamelled, the turns should be spaced accordingly, to bring the coil to the desired length. Only an approximate length is needed. The plastic covered type makes a firmer and better job.

The High Frequency Choke. (Fig. 3)

This is 80 turns of 38G. enamelled wire on a $\frac{1}{4}$ in. dia. former $\frac{7}{8}$ in. long. The former is made of gummed paper wound on a $\frac{3}{8}$ in. dowel. The outside dia. should not be less than $\frac{1}{2}$ in. Apply a thin smear of cement to the outside and dope black if desired. To wind, make a fine hole $\frac{1}{8}$ in. from one end and thread the wire through two or three times, passing it over and over the end of the tube. Fix a hand drill firmly to the bench and place a short length of $\frac{3}{8}$ in. dowel in the drill chuck. The tubing is pushed onto it wired end first. The opposite end of the tube should project clear of the dowel to enable another hole to be made $\frac{3}{8}$ in. from the first. Placing the spool of 38G. wire in a container, hold the wire near the tubing and slowly turn the drill, guiding along the tube. Wind the turns as close and even as

possible, filling up the space between the holes. There is no need to count the turns. Secure the end of the winding in the same manner as the start, making sure the turns have been kept firm and tight. The enamel should be scraped from a small area at each end, with a razor blade, removing as much as possible from between the turns. Smear with flux and tin. A small blob of solder will form, which should contact several turns. Fig. 3 will make this clear. This completes the H.F.C.

The Quench Coils

The formers can be made in two ways. 1. Four 1 in. dia. paxolin discs are cut and drilled $\frac{3}{32}$ in. centres. These are spaced with $\frac{1}{2}$ in. dia. $\frac{3}{8}$ in. thick hard balsa discs. Fig. 4a. 2. Wakefield bobbins can be used, after some modification, making a much stronger and better job. As the gap between the side plates is $\frac{1}{2}$ in., this must be reduced to $\frac{3}{8}$ in. by cutting through the centre (Fig. 4b). Sand or file off surplus, keeping the faces square rejoining with cement. After completing both bobbins, bolt together and wind a $\frac{3}{8}$ in. wide strip of adhesive tape or gummed paper tightly round the centre of each until the required $\frac{1}{2}$ in. dia. is reached. As the centre holes in the bobbins are larger than wanted, fuel tubing should be slipped over the 8 B.A. securing bolt when fixing for winding and later mounting to the bracket, using suitable washers at each end. The Wakefield bobbins will take a 2 B.A. threaded rod. Should the bobbins be of the type as in Fig. 4c cut as before and file the curved shoulder away. Proceed then as in Fig. 4b. The material is quite easy to work. The mounting bracket is shown in Fig. 4d, and should need no explanation. The bolt securing the bobbins is now firmly fitted into the hand-drill chuck. 750 turns of 38G. enamelled wire has to be wound into each section, and in the same direction. This is done in the same manner as the high frequency choke (Photo 2). Before commencing, however, a short length of thicker wire must be soldered to the 38G. Size 26 or 28G.

covered wire will do, about 9 in. long. As the finish of the winding will be treated in the same way, it is advisable to use different coloured wire which will enable the start and finish of each coil to be located when wiring up. It is suggested that enamelled wire for the start, and double cotton or silk covered for the finish, be used. Clean the ends to be joined and twist as shown in Fig. 5. A small piece of Sellotape is covered over the joint to insulate. Two or three turns of the thicker wire are wound round the bobbin centre, the end of the wire being passed up the inside face of the bobbin, being secured to the outer face with sticky tape (Photo 3.). Do not cut off, leaving the few inches for connecting purposes, making sure the thicker wire is wound firmly round the bobbin centre. Wind steadily, holding the wire close to the bobbin, working it from side to side *slowly*, winding hank fashion. There is no need to get the layers evenly placed but watch out for hollows and lumps which can be filled in or avoided as the bobbin fills up. Keep the wire under a fair tension, but do not overdo it, or it will break. 750 turns should just fill the bobbin. The exact number is not important, but get as near as possible. When the winding has been completed the second piece of thicker wire is soldered on. Remember, choose wire with a different covering. Again covering the joint with Sellotape, wind once round the complete coil, bringing the end out near to where the start is located. Before releasing the wire, bind a piece of $\frac{3}{8}$ in. wide adhesive tape once round the coil, thus securing the end. Taking the start, also wind this once round over the tape, covering with a further single layer of tape. The coil should now be as in Fig. 5. Repeat with the other bobbin, making sure to wind in the same direction. A refinement is to cover each coil with Sellotape, overlapping the

bobbin sides and thus holding the complete bobbin together. If it is desired to separate the coils for any reason, mark the inner faces then correct replacement will be certain.

Component Test

When the time comes to switch on the finished receiver, there is always the possibility of 'no joy'. To save later trouble or doubt, it is advised to test the previous components for continuity before final assembly into position. Fig. 6 gives the test circuit, the ends of the various windings being bared and connected to points A and B. A flick of the meter pointer will indicate no break, i.e. a continuous circuit.

The Valve Holder

This should be the type having a black base (AMPHENOL). Remove the aluminium mounting ring. Gently bend back all the tags and fix end of centre tube in the vice. Drill away top of tube and pull base upwards off the tube (Fig. 7b). Carefully drill out centre hole $\frac{3}{16}$ in. dia. A flat is then filed on base side between tags 1 and 7. (Fig. 7 A and C). Drill a $\frac{3}{16}$ in. hole through the side of the base into the $\frac{3}{16}$ in. centre hole (Fig. 7c). Drill carefully, keeping the drill vertical. An 8 B.A. nut is now slipped into the $\frac{3}{16}$ in. centre hole wedging with a sliver of balsa. Thread an 8 B.A. bolt into the smaller hole and work the nut about until the bolt can be screwed onto it. Withdraw the wedge. Before mounting the valve base, one end each of the 3.3 megohms resistance and the 100 pfs. condenser should be soldered to tag 3. The other end of the resistance is soldered to tag 6. The 100 pfs. fixed condenser is adjusted so that the free end can be pushed through the slot in the panel when fixing the base (Fig. 8). A short length of stiff wire, suitably insulated with sleeving, is connected between tags 2 and 4. Bend tag 7 right back against side of base out of the way.

Mount the tuning coil first, pushing up through the appropriate hole, from the underside of the panel. Work the coil

centre tap through the slot afterwards turning the coil until the mounting holes line up. The centre tap should point towards the relay position. One end of the coil winding should also project up through the slot for connection to tag 2, on valve base. Photo 4 (15). The other end of the coil remains below the panel. Two half inch 8 BA bolts hold the coil in position, placing a spacer between coil former and panel (6 BA half nuts will do). Fig. 9A. Place an 8 BA solder tag before screwing on the nut. Photo 5A. 8 BA washers are fitted to all bolts top and bottom. The quench coils are next. They should have the aluminium "L" bracket fitted as follows. A 1 in. 8 BA bolt has first a washer followed by a double-ended tag threaded on. The "L" bracket next, the bolt being passed through both coils securing them with a washer and nut. Do not tighten up hard yet! The START of the inner quench coil is soldered to one side of the tag. (Photo 4B) (Fig. 9B). Mount the coils working the remaining three wires and the foot of the bracket through the square hole provided. (Photo 5C). Fix bracket to panel with an 8 BA bolt. The half inch bolt will be too long. Therefore, cut to length if neater finish is desired. Press coils down firmly into the square opening and tighten the bolt holding them in position. The high frequency choke comes next, one end being soldered to the tuning coil centre tap, the other end of the choke to the free end of the tag on the quench coil mounting bracket. (Photo 4). The choke is mounted direct by means of the two solder blobs previously left at each end (Fig. 3). The positions of the coil centre tap and the tag will have to be adjusted to suit the choke.

To mount the beehive condenser the halves should be separated, the bottom or fixed half being pushed up through the hole provided for it. It should be a tight push fit. On this half will be found two tags. Cut the long one off and turn the condenser until the remaining tag touches tag A on the coil former (Photo 5). Screw on the top half of condenser

fully thus holding the beehive in position until soldered. Cut short the central spike, leaving enough to solder the necessary wires. When mounting the valve base, the balsa wedge is replaced before unscrewing the bolt. Place an 8 BA washer and tag on the bolt, push up through hole in panel (Fig. 1). A non-conductive washer approx $\frac{1}{8}$ in. thick comes next followed by the valve base. Carefully work the free end of the 100 pfs. condenser through the slot, then screw into position with the bolt. Withdraw the balsa wedge and tighten up the bolt (Fig. 10). The relay will, of course, be fitted according to the type used. With the Siemens 73, cut as much of the base away as possible from the contact point end to enable it to be located close to the quench coils. About $\frac{1}{4}$ in. will do. A tag is placed on one of the bolts holding the core and main body to the panel. This will be eventually joined to H.T. and L.T. negative and should be on the underside of the panel (Photo 5H). Fit bolts E. and F. (Photo 4 and 5) with tags, top only for E, top and bottom for F. The relay coil is soldered to these, on top of the panel, one end to E, the other to F. It does not matter which way round the coil is connected. (Photo 4). All the following connections are shown on Photo 5, and are numbered in the order of working. Cover with 2 mm. sleeving where shown.

Assembly by numbers

1. Finish of outer quench coil to tag D held by valvholder mounting screw.
2. One end of .003 fixed condenser G. also to tag D.
3. The free end of the 100 pfs. fixed condenser protruding through the slot also goes to tag D.
4. Start off outer quench coil to tag A. The free end of the .003 condenser to tag A. The end of the tuning coil on underside of panel to tag A. All these connections are soldered together, including the tag on the beehive condenser which should be in position as previously described.
5. About 6 in. of flexible wire (any

All the photographic figures referred to in this chapter will be found on Plate III facing page 32.

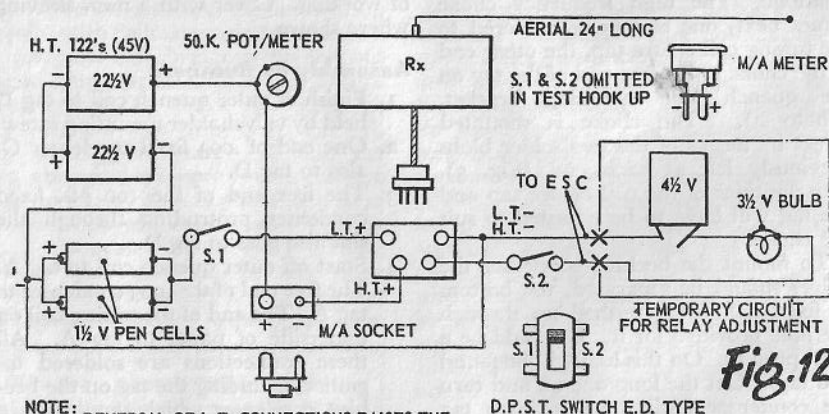
colour but black, red, yellow or blue), is passed between coil former base and panel at S, first loosening the coil former mounting screw nearby. The wire is soldered to the free end of tag A. A short piece of 2 mm. sleeving is then slipped on to the wire and located under the former base. Screw the former bolt up tight gripping the sleeving and aerial wire. This will prevent any tension being placed on the connection to tag A.

6. Connect pin 5 of the valve base to tag H, which is the core and main body of relay. Use black flex and solder to pin 5, first passing wire between 3.3 megohms resistance and valve base and through the slot in panel. Protect with 2 mm. sleeving.
7. Connect about 12 in. of the black flex to tag H.
8. Connect about 12 in. of yellow flex to pin 1 on valve base passing it up through the slot.
9. Connect 12 in. of red flex to tag E, on top of panel passing it up through the hole adjacent (Fig. 1).
10. Connect 12 in. of blue flex to tag K. This tag will vary in position according to the type of relay used. It is fixed under the bolt holding the rear contact, point and in the case of the Siemens 73 should be under one of

the bolts marked X near the lower edge of panel (Fig. 1).

11. The four leads are twisted together and thin fuel tubing slipped over them, the whole being held firm at E, by means of a 6 BA tag or clip. Again, this precaution prevents tension being applied to the actual soldered joints.
12. Connect tag F. to centre pip on beehive condenser.
13. Connect finish of inner quench coil to beehive centre pip.
14. The .01 fixed condenser has one side soldered to tag F, which is one end of relay coil, the other side of .01 going to tag H.
15. Connect the free end of the tuning coil (on top of panel) to pin 2 on valve base (Photo 4). The condenser C.R.1. (.1 mfd.) and resistance R (100 ohms) are joined together and connected across the relay contact points K and H. This spark suppressor, while not essential, definitely prevents dirty points, removing any possibility of faulty contact.

Check all wiring and re-tighten nuts and bolts. The following method of connecting the four pin plug should definitely be carried out. This system, to be carried out on all later connections, is well worth



NOTE: REVERSAL OF L.T. CONNECTIONS RAISES THE STANDING CURRENT BY .2 M/A (APPROX) THUS INCREASING ACTUAL CURRENT DROP

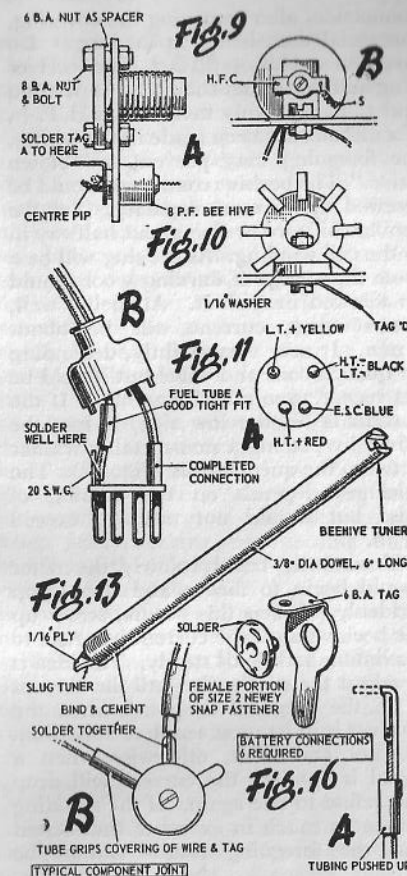
D.P.S.T. SWITCH E.D. TYPE

while, giving trouble-free flying, reducing servicing and, above all, removing any fear of a broken lead while in the air. The model receives a terrific battering on each landing, therefore, joints should be relieved of strain or tension.

Returning to the plug, twist the four coloured leads together, again fitting a short piece of tubing over them, Z (Photo 4). Cut the leads to a suitable length, allowing enough for forward and rearward movement of the receiver. Carefully remove about $\frac{1}{4}$ in. of insulation from each lead and tin. It is immaterial to which pin any lead is connected but suggest as in Fig. 11A. A short length of 20G. tinned wire is placed in the appropriate pin. Now place the correct coloured lead in after slipping a piece of fuel tube on to it. Join up with solder. Push the fuel tube down over the 20G. wire and the flex, gripping the covering tightly to the stiff wire. (Fig. 11B). Proceed with the other leads. By the way, don't forget to thread the aluminium plug cover on before starting! This completes the receiver. The complete theoretical diagram is shown in Fig. 14.

Hook up and Operation of Receiver

Before fitting the receiver in to the fuselage, a temporary hook-up should be made (Fig. 12). The pot/meter is essential in the hook-up, as relay adjustments can only be made with this. The positions of batteries, sockets and receiver should be approximately as shown, although the receiver is not at all "touchy" about this. The aerial position is important, running clear of all other components and wiring. Lay the receiver face up on an inverted box lid, clear of the bench. The switches S1 and S2 in Fig. 12 can be omitted on the test hook up, the L.T. being used to switch on and off. The H.T. battery should be only 45 volts for test purposes, as once the set has been adjusted correctly, it may be increased to suit the relay used. The L.T. battery consists of



two $1\frac{1}{2}$ volt pen cells wired in parallel (Fig. 12). The filament current is only 50 m/a and these will last quite a long time. Note that the L.T. connections are reversed. The wiring is done exactly as shown. The H.T. — will be joined to L.T. — in the wiring but instead of connecting L.T. — to battery — it will go to the battery +. The actual L.T.+ lead will go to battery —. This simple alteration raises the standing current by approximately .2 m/a, the current on signal still dropping to its previous figure. A worthwhile alteration. Join about 18 in. of wire to the aerial lead (Photo 5, 5) by means of a twist

connection, after removing the covering, the aerial then being 24 in. long. Do not connect H.T. + till last. The receiver plug and m/a meter should be in position and L.T. on. Only then attach H.T. +. If a mistake has been made in the wiring, the foregoing may prevent a "blown valve." The beehive condenser should be screwed up to max. capacity. Set the tuning coil core or slug about halfway in to the coil winding. As the slug will be a loose fit, a wisp of darning wool should be screwed in with it. All being well, the standing current will be about 2 m/a. It may vary slightly, depending on quench coils and valve but should be between 1.75 m/a and 2.25 m/a. If the current is on the low side, it may be raised by placing a non-metallic washer between the quench coils (Fig. 4A). The thickness depends on the amount of raise but should not need to exceed $\frac{1}{8}$ in.

Unscrew the beehive slowly, the meter should begin to flicker and then drop suddenly. When this occurs, screw up the beehive until the current just rises to maximum and holds steady. The idea is to adjust the condenser until the current is on the verge of dropping when the receiver is in its most sensitive condition. Do not overdo it, otherwise when a signal is applied, the current will drop and refuse to rise again. If the standing current is much in excess of that stated and the foregoing results cannot be

obtained, check receiver and layout. If correctly made, it must work! Assuming that the standing current is correct, but will not drop, shorten the aerial a few inches. If the current is down (about .8 m/a) with the beehive fully screwed up, lengthen the aerial. The idea is to adjust the aerial length until the critical point occurs with the beehive screwed about halfway in. All this without transmitter on. When satisfactory operation has been achieved, key the transmitter and tune in the signal by means of the slug. A useful and easily made tool for this purpose is shown in Fig. 13. Use no metal for the tuning blade, ply or paxolin being best, preventing de-tuning upon removal. All being well, the current will slowly drop as the slug is turned. Continue until the current shows signs of rising. When this happens reverse turn until the lowest current reading is obtained. This is not at all difficult, as the tuning is quite broad. The idea is to find the centre of the tuning band giving the lowest reading. Key off transmitter and the current should rise. Re-adjust the beehive to its most sensitive setting. Key Tx again and re-tune. The two adjustments interact slightly, but are tuned separately, as neither are critical. The foregoing may sound a lengthy job, but once the positions have been found, will only take a few seconds when re-checking. Incidentally, the Tx

should have low power and reduced aerial to give distant reception results. Get really familiar with the operation of the whole outfit before fitting into the model. With voltages as stated, the current drop should be at least 1 m/a and may be 1.2 m/a (our own Rx gives this drop). Very few readers will possess the SCR 522 relay, therefore, 67½ volts will be needed for other types. The standing current should then be 3 m/a, dropping to 1.15 m/a giving an operating drop of 1.85 m/a. The beehive will need screwing up a little more and possibly a slight re-tune.

Relay Adjustment

The correct operation of the relay is the most important item in the whole radio network. See chapter IV. With this receiver, the relay must be adjusted to operate about halfway between standing current and greatest current drop. A little higher will not be harmful. Remember the drop remains the same regardless of range. As the operating point will be well below the standing current, a valuable safety factor is introduced, for when the H.T. batteries begin to age, ample warning is given by noting the reduced standing current. This reduction will not be enough to bring the relay into action. With a standing current of 2 m/a dropping to say .8 m/a the operating point could be at 1.5 m/a to 1.6 m/a. With the high voltage the following figures will apply 3 m/a standing, down to 1.15 m/a; operating point being approximately 2.25 m/a.

Fuselage Layout

The receiver is not at all critical regarding its position in relation to other components, but the following may help in obtaining easy and consistent results.

The aerial passes out through the fuselage top just behind the wing T.E. and is hooked to the fin with rubber bands. It must not be allowed to trail loosely or hang below the fuselage as was common practice some time ago. Variation in its position during flight will

cause the standing current to fluctuate. The H.T. and L.T. batteries should be mounted on a shelf forward and above the receiver. The socket to take the receiver plug is glued to the fuselage floor just inside the side hatch opening. The actuator battery rests on the floor to the rear of the receiver. The m/a meter socket, on/off switch (D.P.S.T.) and pot/meter are fitted conveniently near the side hatch, again to the rear, all being on the port side. The escapement is mounted near the tail, the wiring passing along the floor of the fuselage. This places it well clear of the aerial. Wire up as in Fig. 12. Keep all wires neat and tidy, taking those from the H.T. and L.T. batteries along the top of the radio compartment, down to their appropriate points. Attach wiring to framework at intervals with Sellotape. When field checking and holding the model by the undercart position, all wiring is clear of the hand. Fig. 16 shows two methods of connecting components, this arrangement being used on all fuselage connections. Newey Snaps Size 2, as shown in Fig. 16A are highly recommended, being brass, ready tinned, and of a convenient size.

Field Check

Field check prior to a flying session is simple in the extreme. First switch on receiver which should, of course, show the normal standing current. Turn down pot/meter and note if relay is working at its correct position. If all correct turn pot to max. Adjust beehive until current is about to drop. Get assistant to key transmitter, the full aerial now being used. Standing several yards away, tune in signal fully. Re-set beehive again. A distant check should then be made about 200 to 300 yards being sufficient. The tuning here will be more critical but not to the point of difficulty. Tune again to centre of current drop, finally adjusting beehive for the last time. Signal assistant to give alternative rudder, remove meter and replace with shorting plug.

As removal of the m/a meter may

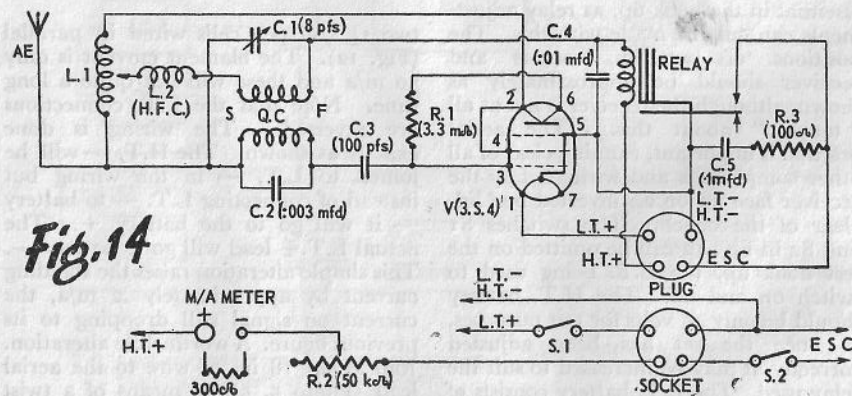


Fig. 14

upset the sensitivity setting (the Beehive Cond.) causing the Rx current to drop or get too critical, a 300 ohms resistance must be wired across the plug used for shorting purposes, instead of the normal direct wire. (Figs. 12 and 14). If your m/a meter is of the low resistance type (approx. 7-10 ohms) the resistor can be

permanently fitted across the actual socket, in which case the shorting plug will not be needed upon removal of the meter. Its effect on meter readings is negligible except on high resistance meters when the shorting plug should be used with resistor fitted.

Use a self neutralising actuator.

List of Component Parts

for the

'AEROMODELLER' No. 1 Hard Valve Receiver

Component List	Approx. Retail Price Inc. Tax	
	s.	d.
1 Paxolin Panel $3\frac{1}{2}$ in. \times $2\frac{1}{2}$ in. \times $\frac{1}{8}$ in. ...	...	...
1 7 or 8 pfs. Phillips Beehive Condenser ...	1	6
1 $\frac{3}{8}$ in. Aladdin Former with Slug. (See Text) ...	1	1
1 3.3 megohms Resistance ($\frac{1}{4}$ th Watt) ...	6	
1 100 pfs. Fixed Condenser. (Tubular Ceramic) ...	1	0
1 .003 mfd. Fixed Condenser. (Hunts Miniature) ...	1	3
1 .01 mfd. Fixed Condenser. (Hunts Miniature) ...	1	6
1 B7G Button Valve Base. (Amphenol) ...	1	0
1 Relay. (sigma SCR522, Siemens 73, E.C.C., E.D., etc.) ...	35	0
1 Valve 354 ...	15	3
1 4 Pin Polarised Plug (Miniature) ...	6	
Quantity 38G. Enamelled Copper Wire. (2 oz. Reel) ...	2	9
2 or 3 yards each of RED, BLUE, BLACK, YELLOW and WHITE Lightweight plastic covered stranded wire ...	yd. 1	$\frac{1}{2}$
1 doz. 8BA $\frac{1}{2}$ in. length Bolts and full nuts (Brass or cadmium plated steel) ...	10	
2 doz. 8BA Washers ...	4	
1 doz. 8BA Solder Tags (double ended preferred) ...	5	
1 yard 2 m/m Systoflex Slewing ...	4	
1 1 in. 8BA Bolt ...	1	
The following components, while not essential, are strongly recommended as spark suppressor and are fitted across the relay contact points :		
1 100 ohms Resistor ($\frac{1}{4}$ th or $\frac{1}{2}$ Watt) ...	$\frac{1}{2}$ Watt	6
1 .1 mfd. Fixed Condenser. (Hunts). High voltage type not essential ...	...	1 3
Components required for attachment to fuselage :		
1 50k ohms Potentiometer (Miniature) (25k or 100k will do) ...	...	3 9
1 On-Off Switch. Double pole Single Throw (D.P.S.T.) E.D. Flat Type ...	...	3 9
1 4 pin Polarised Socket ...	...	6
1 2 pin Polarised Socket ...	...	6

APPROX \$7.604

Chapter Ten

The Pike Miniature Receiver

ONE of the most successful miniature XF G1 Receivers the author has encountered was built by Geof. Pike of Nottingham in 1952. Geof. has since made several attempts at a World Record for radio controlled models, and on 11th July, 1954, finally achieved his ambition with a flight of 1 hour 40 minutes and 35 seconds.

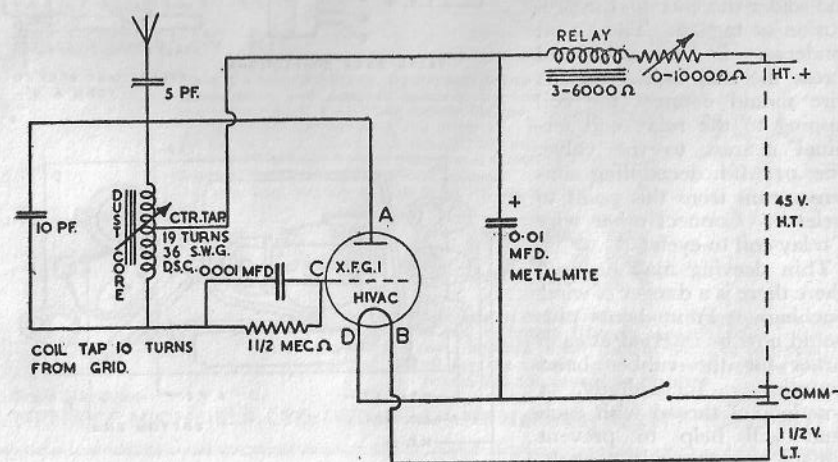
Over to Geof. then for a description of his receiver:

"Step by step details are given, including a drilling template, which may be pricked straight on to the paxolin base with a scribe; this will be a great help in the component spacing, which has a definite effect on the performance of the receiver and will add speed to its assembly.

The valve socket should first be mounted, using a small eyelet. Then cut the dust-iron cored tuning coil former to $\frac{11}{16}$ in. overall length, remove one lug and mount with 10 B.A. screw and nut,

also clamping a small soldering tag underneath, bent at right angles and facing inwards. Now add eyelets at holes 7 and 15 and fix the 4 cut-down soldering tags beneath the panel at holes 2, 3, 4, and 14 with eyelets. The relay may now be added and is held by two screws at holes 6 and 8 with tension adjustment through No. 9. This is an E.C.C. type and, in the writer's case, was a faulty one, in which the coil was rewound to 3,000 ohms with No. 47 s.w.g. enamelled copper wire.

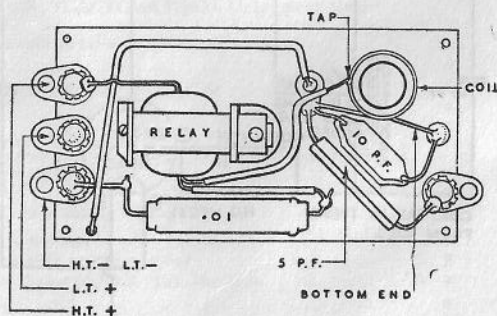
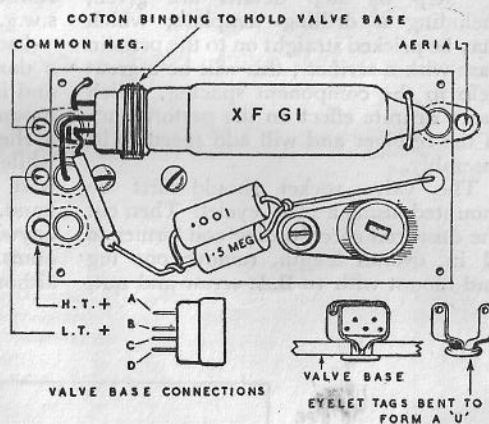
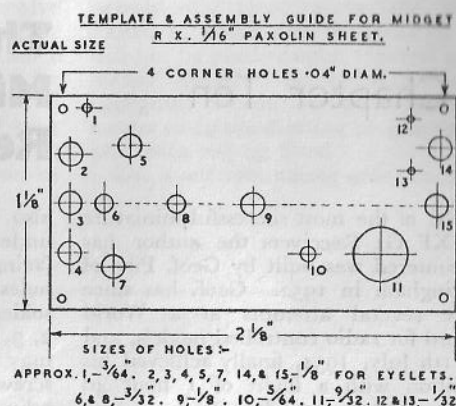
Incidentally, this can sometimes save a damaged relay from the scrap heap, and is quite easily done if the bobbin is mounted on a small electric motor, with a rheostat controlled by the left hand, while the wire is fed through a small wad of cotton wool held in the right hand. The relay resistance can be anywhere between 3,000 and 6,000 ohms. If much higher than this, although more sensitivity is possible, the



H.T. battery will have to be discarded at a higher voltage. Valve base connection D is soldered directly to eyelet 2, a short length of wire connects B to eyelet 3, and another short length connects C to eyelet 7. From A, an insulated wire runs through hole 1 and under panel to tag at hole 10.

The 5 pf. aerial condenser is soldered between eyelet 14 and tag at 10, leaving a short vertical protrusion after soldering through the tag. The .0001 Mfd. grid leak condenser should now be soldered across the $1\frac{1}{2}$ megohm resistor, as shown, and then the pair should be soldered between eyelets 7 and 15, but allowing the wire to protrude about $\frac{1}{8}$ in. through eyelet 15. Now for the tuning coil. Solder one end of a length of 36 s.w.g. silk covered copper wire around the last mentioned protrusion, and leaving a small clearance at the bottom, wind on 10 closely spaced turns; form a loose loop at this 10th turn, and twist up just to the right of tag at 10. Now wind another 9 turns, keeping it tight and neat, and solder the end to the protrusion at tag 10. The 10 pf. condenser is now soldered across the coil as shown. A wire should connect the coil tapping to the relay coil terminal nearest to the valve. The .01 Mfd. decoupling condenser runs from this point to eyelet 2. Connect other wire of relay coil to eyelet 4.

Thin sleeving may be used where there is a danger of wires touching. Four bent pins should now be inserted at each corner for the rubber band mounting. Incidentally, a loose loop of thread with each band will help to prevent damage to receiver in a crash,



without stiffening the suspension. A thin piano wire clip pushed into holes 12 and 13 will keep valve firmly in place, and this completes the receiver.

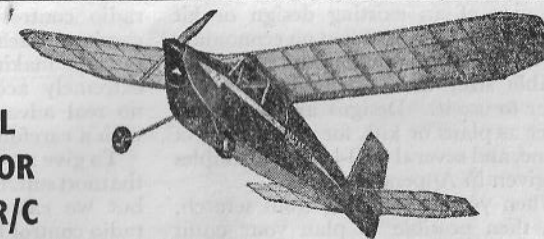
A few fibres of cotton wool are placed in the coil former threads to prevent the tuning from moving when subjected to vibration.

Operation is quite straightforward, and the current change in the writer's receiver is from 2.0 m.a. to 0.2 m.a. at 500 yards, using a 48-in. trailing aerial, but the aerial length is not critical. On the fourth flight of the writer's model the aerial was accidentally pulled off 4 ins. from the set as the model was launched, yet the control was not impaired in any way! In case 2 m.a.

standing current sounds a little high for this valve, it might be mentioned that the writer has obtained over 6 hours operation to date, using 2 m.a. standing current on this receiver, and it is still giving excellent results."

As the 2 m.a. standing current mentioned by Geoff is a little high, according to the author's earlier remarks perhaps the situation should be clarified. There is no harm in using a high standing current with the XFG1, and the performance may well be slightly improved. On the other hand if you need to count your pennies, then the valve will definitely last longer if the normal limit of 1.6 m.a. is not exceeded.

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Chapter Eleven

CHOICE of a model suitable for the purpose in mind is one major problem that confronts the newcomer to radio control. Many aeromodelers will wish to design their own model which is most commendable, but not altogether wise for a first venture. There will be problems enough becoming acquainted with the new field of radio, and it is therefore most desirable that the tyro can concentrate on this aspect without distraction. In other words build a tried and proven design for your first attempt, and follow your own design trend at a later date when you have gained "radio" experience. As yet there are few kits and commercial designs which the author can recommend unreservedly. They nearly all need modification in some respect or other, and a few general remarks regarding construction which can be applied to them all are given in this chapter.

Choice of an existing design or kit depends to a certain extent on economics. If you already possess an engine of suitable size, then obviously you will prefer to use it. Designs are available, either as plans or kits, for most sizes of engine, and several well-known examples are given in Appendix III.

When you are starting from scratch, it is then possible to plan your outfit practically and economically, so let us assume that this is the case and discuss first the question of size.

The author's first radio model was Dr. Walter Good's famous "Rudder Bug" design. It was an excellent model to handle, being extremely stable and docile under control. It was, however, some six feet in span and weighed seven pounds odd, so that when the somewhat unreliable receiver used at the time decided to misbehave, "Rudder Bug" hit the ground rather hard. Another time it was flown into the side of a Nissen Hut through a baulky motor coupled with inexperienced piloting. On

The Model

both of these occasions the model was extensively damaged, the fuselage in particular needed completely rebuilding. Even allowing for the inherent weak spot in a "Rudder Bug" fuselage, it was obvious that the sheer mass of such a large model was responsible for the extensive damage to the airframe. It was further apparent that had the model been considerably smaller and lighter, then damage would have been negligible. This elementary train of thought was subsequently proved correct, and the four feet span design produced to conform to this theory did in fact hit the ground in a vertical dive on many occasions with only superficial damage such as tissue tears as a result.

Harping back to economics it should be pointed out that the large model of six feet span and upwards costs a tidy sum in materials. Its advantage for radio control purposes is that it can carry a sizeable payload, the roomy fuselage making the radio compartment extremely accessible. Even this gives no real advantage over a small model with a carefully planned installation.

To give an exact size of model as being the most suitable would appear dogmatic, but we can safely say that the ideal radio control trainer is between four and five feet in span, has a wing loading of between twelve and fourteen ounces per square foot, and is powered with a $1\frac{1}{2}$ to $3\frac{1}{2}$ c.c. motor.

It should be of robust construction, and strictly functional from all aspects. Looks are of secondary importance to stable performance and the ability to take hard knocks.

Fuselages

The Fuselage of a radio control model needs strengthening, particularly at the front end, and it is well worth sheeting from the nose, back to just aft of the trailing edge of the wing. There is

usually a former at this juncture which makes a convenient finishing spot for the sheeting. Another excellent tip employed by Sid Allen, one of the leading lights in the radio field, is to sheet cover the inside of the radio compartment. Not only does this considerably increase strength, but it also prevents damage to the receiver in hard landings as there are no uprights or crosspieces for the receiver to knock against. (Fig. 1, Chapter XII.)

Make certain that the main formers, particularly those supporting the wings, undercarriage, engine bearers, etc., are of

plywood, or at the least ply faced. These important members take all the sudden stress of heavy landings and collisions, so it is essential that they are fracture proof. This is particularly important in the case of cabin models, and if you are using an existing design where the centre of these formers is fretted away, keep the fretting away to a minimum. It is also a good idea to gusset the internal corners of the formers. See to it that all joints in your radio model are pre-cemented, the extra time that this involves is doubly worth it. Again when glueing hardwood

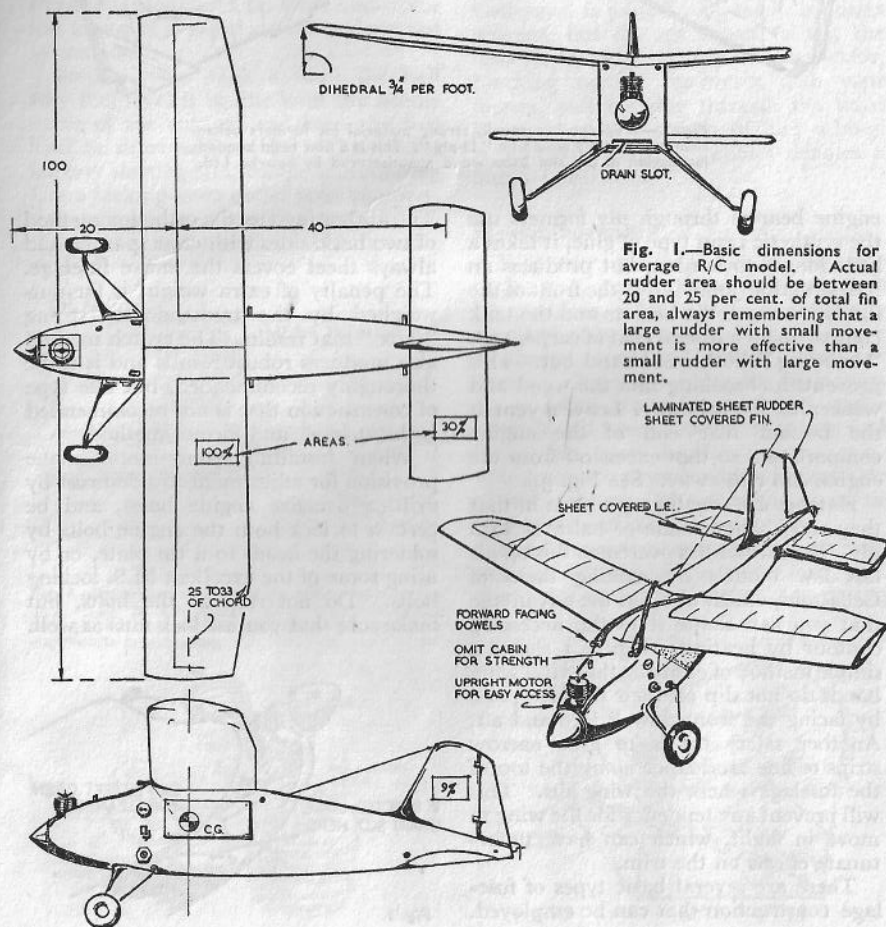


Fig. 1.—Basic dimensions for average R/C model. Actual rudder area should be between 20 and 25 per cent. of total fin area, always remembering that a large rudder with small movement is more effective than a small rudder with large movement.

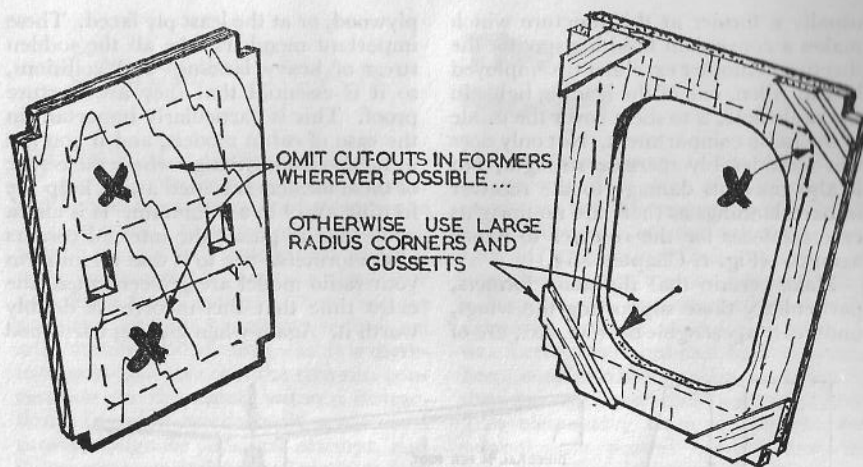


Fig. 2.—A lighter but equally strong material for formers other than ordinary ply would be "Li-ply". This is a new resin bonded lamination of ply and balsa wood manufactured by Solarbo Ltd.

engine bearers through ply formers use the synthetic resin type of glue, it takes a little longer to harden, but produces an indestructible joint. Give the front of the fuselage around the bearers and the tank compartment a liberal coat of carpenter's "knotting" both inside and out. This prevents fuel soaking into the wood and weakening the structure. Leave a vent at the bottom rear end of the engine compartment so that excess oil from the engine can run away. See Fig. 3.

Hatches are usually a problem in that they warp when made of balsa or thin ply. The author has overcome this on his last few models by making them of Cellastoid, which also has the advantage that you can shape it to the necessary contour by heating. Figure 1 shows a simple method of ensuring that vital wing bands do not slip off their fuselage pegs, by facing the front dowels fore and aft. Another safety tip is to glue narrow strips of fine sandpaper along the top of the fuselage where the wing sits. This will prevent any tendency for the wing to move in flight, which can have unfortunate effects on the trim.

There are several basic types of fuselage construction that can be employed.

The author favours the orthodox method of two basic sides with cross spacers, and always sheet covers the entire fuselage. The penalty of extra weight is far outweighed by the tremendously strong "box" that results. The crutch method also produces robust results and is to be thoroughly recommended, but one type of construction that is not recommended is the stringer and former method.

When installing your motor make provision for adjustment to sidethrust by drilling oversize engine holes, and be certain to lock both the engine bolts by soldering the heads to a tin plate, or by using some of the excellent M.S. locking bolts. Do not stop at the bolts, but make sure that you use lock nuts as well.



Fig. 3.

DO NOT FORGET LOCKING NUTS.

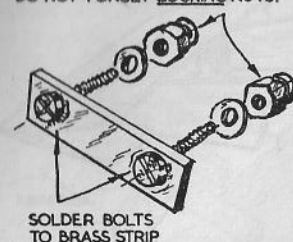


Fig. 4.

Remember that the engine in a radio job runs a lot longer than the average free-flight model. It has been known for the motor of a radio model to drop out in the air!

Position your tank so that the half way fuel level is in line with the needle valve of the engine, and keep the fuel lead as short as possible. This makes for easy starting and trouble-free running. Use a locking lever under your compression adjustment screw like they did on the cross channel model. This is easily

Fig. 5.

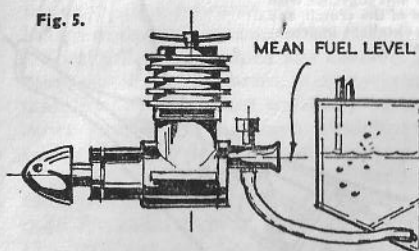
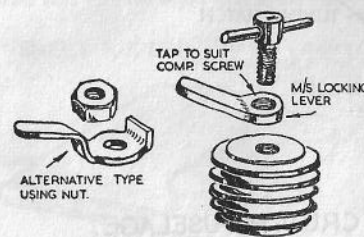


Fig. 6.—Prolonged running of the radio model engine may result in the compression screw slackening through vibration. This locking system is therefore a worthwhile modification.



fabricated from a piece of mild steel tapped with the appropriate hole.

Tanks can be made from tinplate or from Cellastoid. The author prefers the latter material as it is transparent, enabling the fuel level to be ascertained at a glance. Unless you are going in for stunt flying a baffle is not strictly necessary but is very little extra trouble to include. A tank shaped as in Fig. 1 can be positioned between the engine bearers immediately behind the engine bulkhead, and attached by cementing small blocks of Cellastoid each side which rest on the top of the bearers. Incidentally, Cellastoid is joined very easily by balsa cement, but do not forget to test the tank for leaks by holding it under water, blocking two of the vents with your fingers, and blowing through the third by means of a length of fuel tubing. A tell-tale stream of bubbles denotes a faulty joint.

Flying Surfaces

Wherever possible use a one-piece mainplane, particularly if transport is no problem. Mainspars, if originally specified of balsa, should be replaced by hardwood spars of either birch or spruce. *Never* use balsa for mainspars on a radio control model for under stress it will break. Birch or spruce will stand far more bending strain, providing a much more flexible wing capable of withstanding the somewhat excessive loads that are likely to be applied.

Sheet cover the centre section on both top and bottom of the mainplane, and if you can stand the weight, then do the

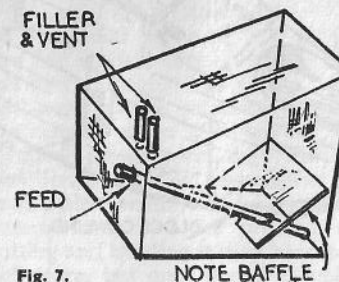


Fig. 7.

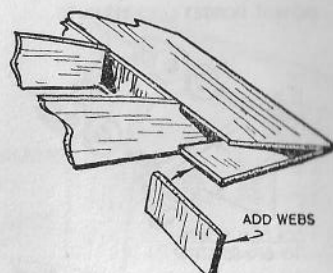
PLY DIHEDRAL BRACE.



Fig. 8.—Plywood spar braces are essential, and on larger models may also be fitted to leading and trailing edges.

same for the entire wing, from the leading edge back to the mainspar. This is best carried out with soft $\frac{1}{8}$ balsa rather than $\frac{1}{4}$ as the latter shrinks badly under the influence of balsa cement. Starting with the thicker $\frac{1}{8}$ and sanding it down produces far better results.

Use built up trailing edges cut from $\frac{1}{8}$ balsa, as in Figure 8. They are

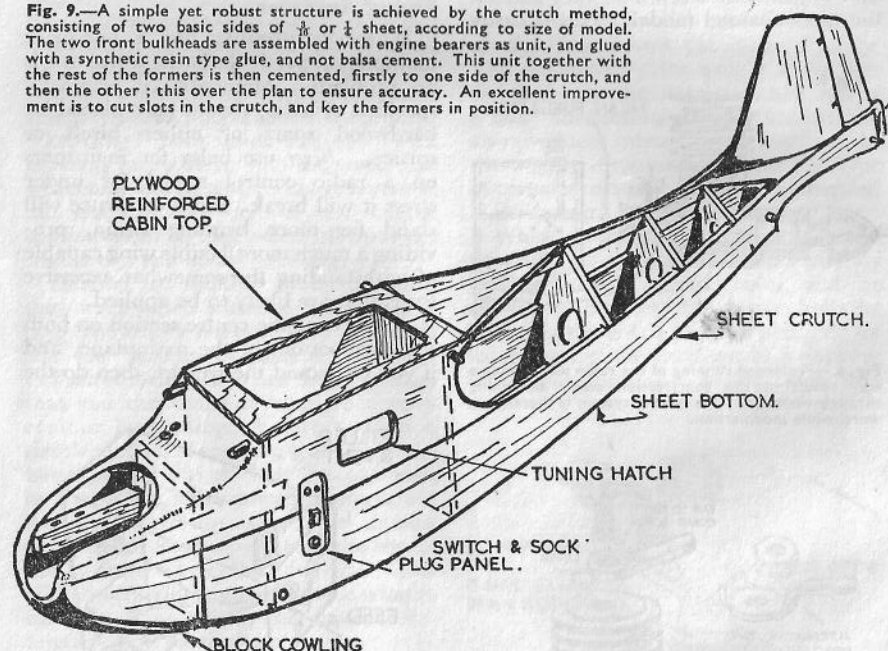


BUILT UP T. E.

stronger and more flexible than the solid variety, and will do for models up to six foot span. On large models use capping strips which again make for extra strength, and also give a more finished appearance to the wing.

For covering material one cannot beat silk or nylon. Admittedly they are

Fig. 9.—A simple yet robust structure is achieved by the crutch method, consisting of two basic sides of $\frac{1}{8}$ or $\frac{1}{4}$ sheet, according to size of model. The two front bulkheads are assembled with engine bearers as unit, and glued with a synthetic resin type glue, and not balsa cement. This unit together with the rest of the formers is then cemented, firstly to one side of the crutch, and then the other; this over the plan to ensure accuracy. An excellent improvement is to cut slots in the crutch, and key the formers in position.



SHEET CRUTCH FUSELAGE.

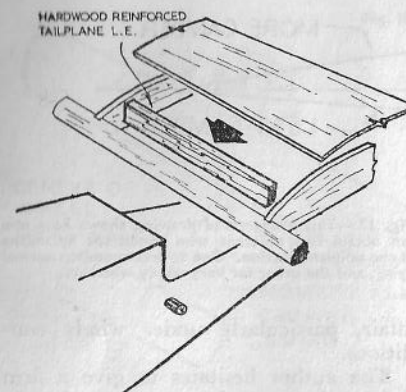
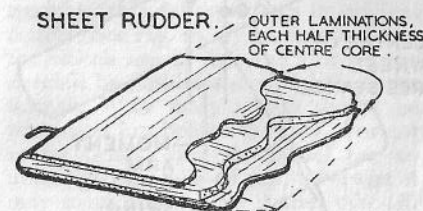


Fig. 10.—The sudden shock of a heavy landing is prone to either crack or dent the leading edge of the tailplane where it meets the fuselage. To prevent this, reinforce the structure at this point with a strip of hardwood glued along the leading edge between the centre ribs.

expensive and also add weight, but with all the rough usage that the average radio model gets they cannot be beaten. Most people use them on models from five feet span upwards, but the author knows of several versions of his four feet "Sparky" design which are covered in these materials. If you are sheet covering your fuselage it is not necessary to use other than the well-known Modelspan, which is the strongest of the paper coverings, and available in two grades. Heavyweight Modelspan is extensively used for radio models, and is certainly the toughest of the covering papers. A plasticiser should be used in the finishing dope when any form of paper covering is employed, as this prevents

Fig. 11.—Rudders should be made from laminated sheet balsa with the hinges inset in the centre layer.



the covering shattering should you have any hard knocks. The plasticiser in this case, consists of a few drops of castor oil, which with some commercial brands of dope may already have been added.

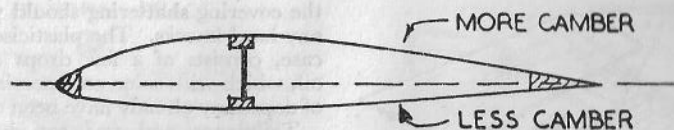
Tailplanes and fins can be of all balsa construction, and again it is well worth sheeting the leading portions of both these surfaces. With smaller models this is only necessary on the upper surface of the tailplane, but the centre section should be sheeted both sides.

On large models the rudder should be built up as this produces a more warp-resistant structure. Most medium and small size models use a solid rudder, but this should not be cut from a single sheet of balsa as it will almost certainly warp when you dope it. Make a sandwich of two or three layers of smaller section wood positioned so that the grain counteracts warping tendencies. Do not use shrinking dope on the rudder as it is unnecessary. A coat of Sanding Sealer and then the finishing dope are all that are needed, and even these will do their best to warp your anti-warp sandwich!

Undercarriages

Undercarriages, or landing gear as our American friends more practically describe them, need careful consideration on a model intended for radio control flying. For a start they must endure considerably rougher usage than is normally encountered on the average free flight model. Even a smallish radio job hits the scales at around the two pound mark, and two pounds travelling at anything up to 30 m.p.h. can do a lot of damage if not set down right.

The normal 12 or 14 S.W.G. piano wire leg without any springing simply isn't good enough. For a start it is too rigid and has to be constantly bent back into original shape after landing. The so-called piano wire that the aero-modeller has endured in post-war years, bears little resemblance to the genuine material we used in pre-war days. Cutting and bending it may have been a nightmare, but once done, it could be



REVERSIBLE STABILISER

relied upon to stay in its original shape under the cruellest of circumstances. Perhaps some enterprising manufacturer will investigate its disappearance from the market and produce the real McCoy. If he does, he will earn the gratitude of all radio fliers, and do good business at the same time.

Probably the first question the newcomer will ask is whether the normal two-wheeled undercarriage is better than the tricycle type he sees on many well-known designs. The answer to this one depends on the user's requirements. The tricycle gear does permit trouble-free ground take-offs even under gusty conditions, its one disadvantage lies in the nose-wheel. On landing, this unfortunate portion of the gear always smites the ground first, getting far more than its fair share of normal wear and tear. Even with the best of design schemes the nose-wheel is a constant headache and needs replacement at regular intervals.

The orthodox two-wheel gear is easier to maintain but does make take-offs from the ground a more chancy

Fig. 12.—This exaggerated drawing shows how one can obtain two different trim conditions by means of the tailplane section. One to accommodate normal flying, and the other for very windy weather.

affair, particularly under windy conditions.

The author hesitates to give a firm opinion between the two types, but in broad principle would say that the tricycle gear is more for advanced flying, and the two-wheeled variety the best bet for the beginner. After all, with one's first model the aim is to gain as much trouble-free flying experience as possible and this is best achieved by maintaining the simplest possible equipment. One can in any event always convert to tricycle undercarriage at a later date if the urge to try three wheels becomes irrepressible.

Whether you intend using two wheels or three wheels, it is important to know where to position the undercarriage for best results. Study Fig. 13 which shows a normal two-wheeled aircraft with the wheels positioned well in front of the C.G. The resistance to forward movement acts on the wheels, and at the same

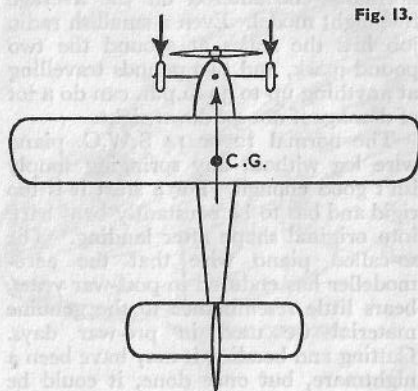


Fig. 13.

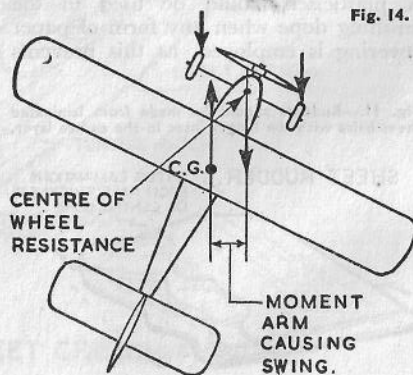


Fig. 14.

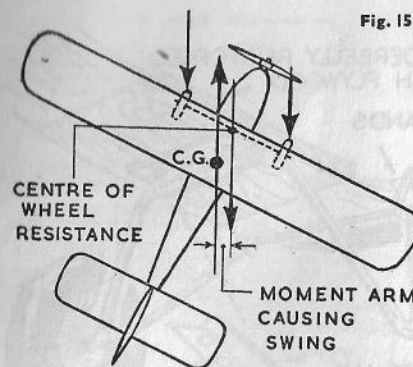


Fig. 15.

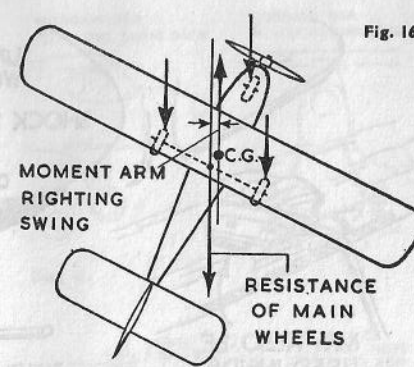


Fig. 16.

time the model can pivot sideways on the wheels. If a gust of wind or a bump cause the model to swing sideways, the C.G. will not then be following behind the mid point of wheel resistance. Since the wheels are now trying to go sideways their resistance increases, and the momentum of the model acting about the C.G. swings it completely round in what is known as a ground loop, see Fig. 14.

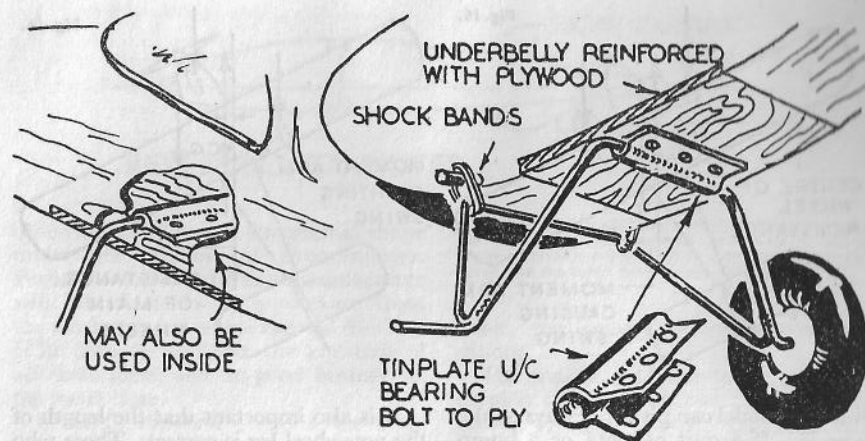
By moving our undercarriage rearwards, i.e. nearer to the C.G., to a position under the leading edge of the wing, we decrease the moment arm between the centre of wheel resistance and the C.G., and accordingly decrease the tendency to ground loop—Fig. 15. We pay a slight penalty by doing this as the model will be more prone to tip on its nose when landing, but with present-day plastic props and the resulting improvement in take-off characteristics, it is a design feature well worth remembering.

The case of the tricycle undercarriage is rather different. The main wheels are positioned behind the C.G. so that the momentum tends to pull the machine straight if it is deflected from its original course. See Fig. 16. It is important that the wheels are in line and this can be checked by pushing the model along the tarmac. The main wheels should be positioned just behind the C.G., but not so far behind that the model has an unusually long take-off run, otherwise it may zoom and then stall after take-off.

It is also important that the length of the nosewheel leg is correct. Those who have seen a full-size tricycle undercarriage aircraft land will appreciate that it does so in a nose-up attitude, so that the main wheels touch down first. Then as the machine loses momentum the nose slowly drops, until all three wheels are taking the weight. This is how we would like our model to land, but unfortunately, we have not the degree of control necessary, and our model makes its landing approach along its normal glide path, which in relation to the horizontal is probably at an angle of approximately 20 degrees. Obviously, the shorter we can make the nose leg the better, but here a compromise must be reached, as the more nose-down the attitude of the model at rest, the more likelihood there is of the model failing to unstick, and the more possibility of it zooming and stalling after take-off.

Sprung Undercarriages

Many people, including the author, use a method of undercarriage springing incorporating rubber bands (Fig. 17). The scheme is self-explanatory and has the advantage that the tension of the bands may be varied to suit the landing conditions available. Furthermore, the bands are replaceable, and come to that, so is the complete assembly if mounted on the underside of the fuselage as shown. The author has also tried this scheme for



the nosewheel on a tricycle model, but it failed to prove a permanent and practical proposition.

Torsion Bar Undercarriages

Certainly for nosewheels a torsion bar arrangement is the best answer, see Fig. 17. The distance of the main torsion tube from the bulkhead should be as little as possible, $\frac{1}{2}$ inch being sufficient for most leg sizes. The spring is derived through twisting the transverse "torsion bars" within themselves, and the longer they are made, the more springy the leg will be. The "torsion bars" are held loosely together by a piece of tin plate wound two or three times round them to form a torsion tube. The tube is soldered so that the layers are bonded together, but the tube *must not* be soldered to the "torsion bars" themselves. The leg is formed from a single length of piano wire, 12 S.W.G. being suitable for large models up to 6 lb., and 14 S.W.G. being sufficient for smaller models of around the 2 to 3 lb. mark.

The nosewheel, like all nosewheels, should have a solid or sponge rubber tyre. Never use a pneumatic wheel for this job, unless you like to make it "solid" by filling the tyre with scraps of sponge rubber.

We are indebted to F. Brian Thomas for introducing the torsion bar under-

Fig. 17.—Above is the method of undercarriage springing where the legs swing rearwards against the tension of rubber bands. Below, a nosewheel assembly on the torsion bar principle, the torsion being applied where the crossover occurs. U-bolts hold the wire securely to the bulkhead, and the top tube wound from tinplate, secures the two ends of the single length of wire.

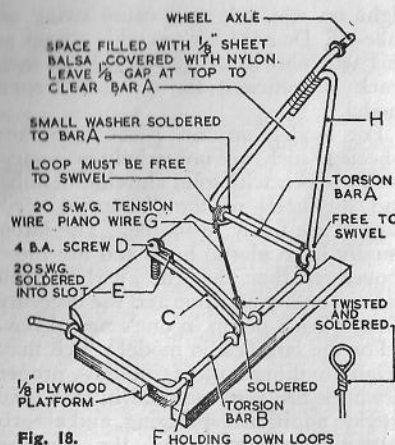
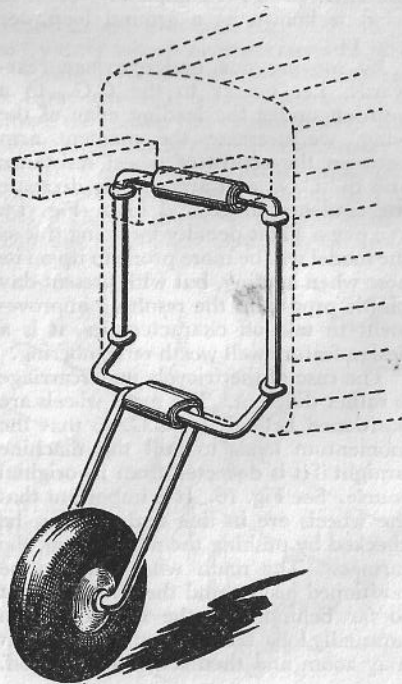


Fig. 18.

carriage to acromodellers, and also recommend his scheme for the main undercarriage legs which can be detailed as follows.

Using wire one size thicker than the gauge specified for the nose wheel, form the main leg which runs in one piece from axle to axle (Fig. 18). Both wheel axles must be inclined so that the wheels slope inwards as in Fig. 19b. When the full weight of the model is on the undercarriage the wheels should then be vertical. The splaying action is taken care of by torsion bar "A". For a heavy landing the whole undercarriage leg can swing back as shown in Fig. 19a. The swing back is allowed by torsion bar "B", which is pre-tensioned, or pre-tensioned, by tightening up milled nut "I" on screw "D". As nut "I" is tightened, the screw "D" pulls "C" towards the plywood platform, thereby increasing the torsion in bar "B". Note the 20 S.W.G. locking pin which is soldered to the slot in the screw "D". Tension wire "G" is firmly soldered to "C" as shown in Fig. 18. This wire is also twisted back on itself and soldered at each end. The subsidiary leg "H" is made of 16 or 18 S.W.G. piano wire, formed into a loop where it encircles torsion bar "A", and must be free to swivel.

The method of anchoring this, and any

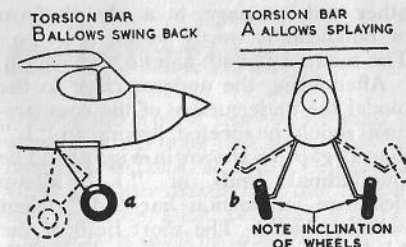


Fig. 19.

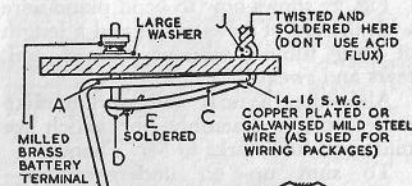


Fig. 20.

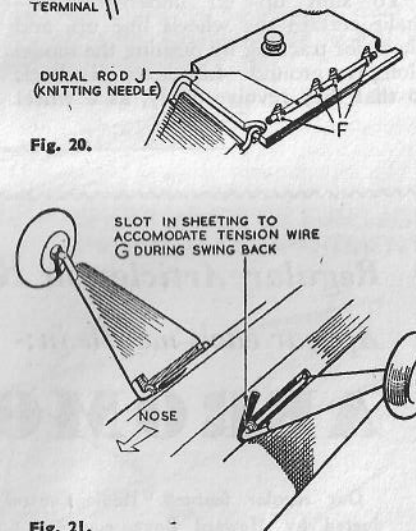


Fig. 21.

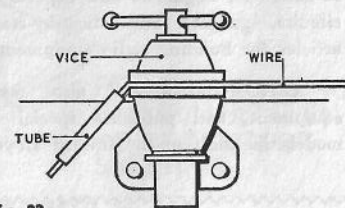


Fig. 22.

other undercarriage, to a ply platform or bulkhead is worth noting (Fig. 20). The method is both simple and strong.

After fitting the undercarriage to the model the undersurface of the compartment should be sheeted, leaving an "L" shaped gap, as shown in Fig. 21. The longitudinal limb of "L" allows clearance for torsion bar "A" when swinging back. The short limb of the "L" accommodates tension wire "G". Even when the undercarriage swings back the wheels maintain their correct track.

Fig. 22 shows how to bend piano wire with the aid of a stout vice and a length of strong tubing, without "blood, toil, tears and sweat"!

Altogether a neat and workmanlike undercarriage assembly, for which we must give full marks to Mr. Thomas.

To sum up on undercarriages—make certain the wheels line up, and check for tracking by pushing the model along the ground. Lubricate all wheels so that they revolve freely, as a wheel

tight on one axle will cause swing on take-off. Do not have too wide a track as this will also cause swing. A 12 inch track is sufficient for a six feet span model.

For models around 4-feet span, airwheels as such, are not strictly necessary. Sorbo wheels with solid aluminium hubs, and airwheels of the "trapped air" variety are freely available. The latter usually have plastic hubs and are more convenient than the true airwheel with its accompanying valve and the necessity of carrying a pump in one's model box.

For the large radio model which may weigh anything up to 15 pounds, proper airwheels are very essential in that they provide additional springing, and absorb a useful proportion of the landing shocks. They should be looked after carefully according to the maker's instructions, and particular attention should be paid to maintaining equal pressure in the two main wheels, otherwise bad tracking will result.

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Chapter Twelve Installation

METHODS of installation vary to a certain extent and many experts have their own pet ideas as to where particular items should be positioned. There are, however, basic factors which govern the positioning of radio control equipment in a model aircraft.

For a start the vulnerability of most radio control receivers necessitates that they be well protected against damage in a heavy landing or even in a crash. For this reason the receiver is usually placed in the strongest part of the fuselage. In the orthodox model the fuselage is invariably at its strongest underneath the wing, and as this is also the widest part of the fuselage, it is the most convenient spot from many points of view. Fig. 1.

With the type of receiver we shall be using it is essential that leads from the batteries be kept as short as possible, which in turn means that our receiver and batteries must be close together. The receiver must be mounted in such a way that the vibration from the engine has no detrimental effects on sensitive components such as the relay. One common method of mounting is to suspend the receiver between taut rubber bands attached to each corner of the receiver panel by means of metal hooks (see Fig. 2). Fairly stout rubber bands should be used for this job and they should be tight enough to prevent the receiver hitting the bulkhead in front of it, when the aircraft comes to a dead

BASIC FUSELAGE FOR R.C.

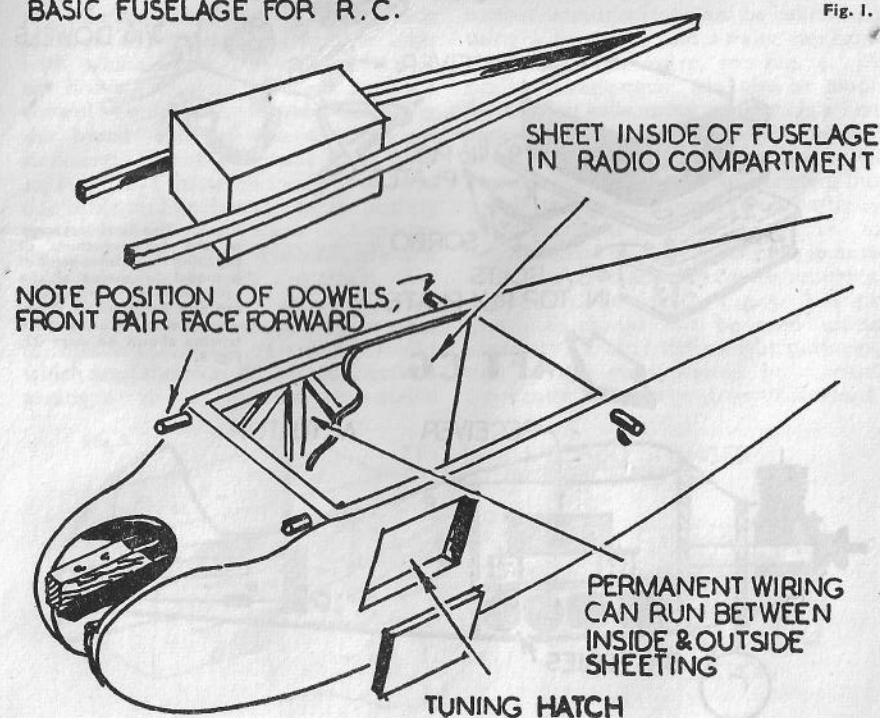


Fig. 1.

stop from speeds of 30 m.p.h. downwards. Grasp your fuselage at the tail end and push it violently backwards and forwards along the floor with the receiver mounted in position. If the receiver shows any tendency to hit either the front or rear cabin bulkheads, then strengthen your mounting bands. As a further precaution glue sorbo rubber shock pads to the

bulkheads directly in front and behind the set, so that should you have a really bad landing and maybe break the bands, the receiver does not suffer. An excellent alternative is to cut the centre from a Woolworths sponge so that it fits around the receiver. Fig. 3.

Another method of mounting is to attach the receiver to a sorbo rubber pad

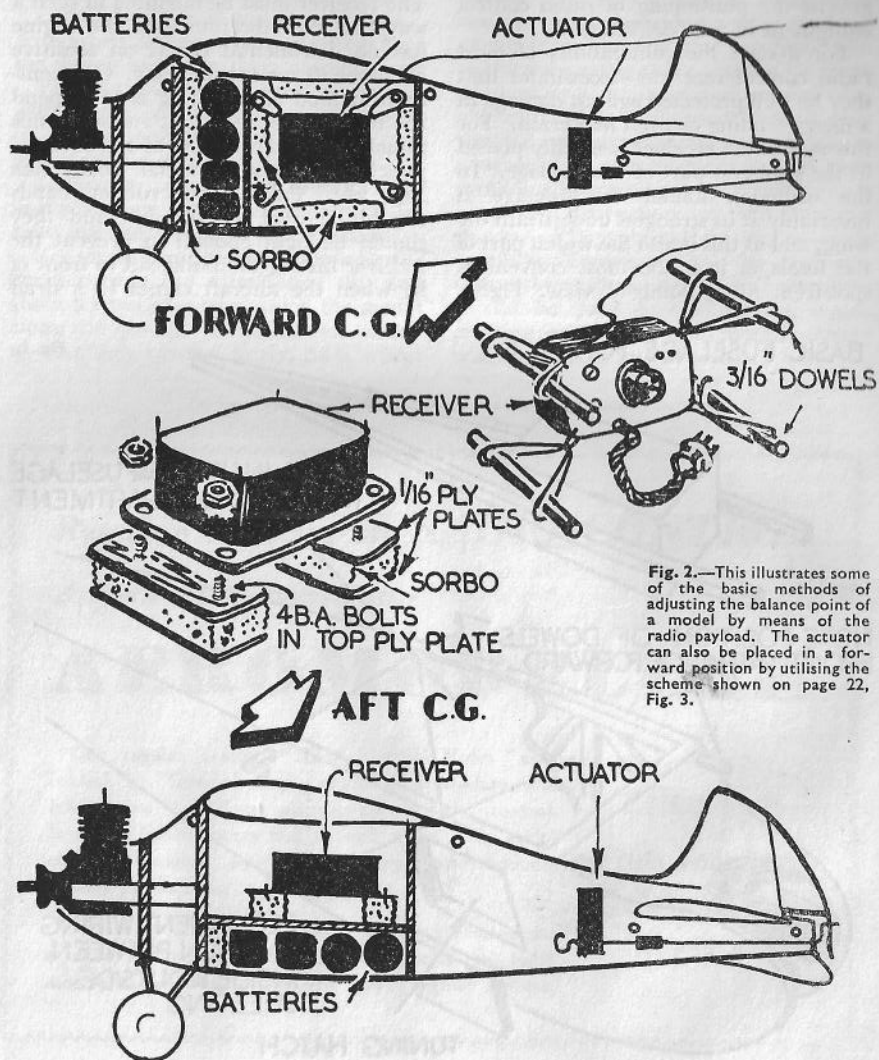


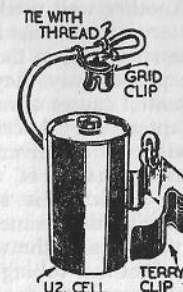
Fig. 2.—This illustrates some of the basic methods of adjusting the balance point of a model by means of the radio payload. The actuator can also be placed in a forward position by utilising the scheme shown on page 22, Fig. 3.

sandwiched between pieces of plywood as in Fig. 2. The plywood is glued to the sorbo by means of "Bostick" and the top pieces have bolts inset. The receiver has a hole drilled in each corner and drops over the four bolts being secured by 4BA nuts. This same scheme can be adopted with the receiver mounted vertically on the rear face of the main bulkhead.

Now for the batteries which are the weightiest part of our airborne equipment. The high tension batteries which usually consist of either two or three B 133's or B 120's are invariably the heaviest. They are of the layer type and very much prone to internal resistance if the layers are forced apart, as often happens when taped hard together. A thin pad of soft paper or sorbo rubber should therefore be inserted between the batteries which will prevent any such occurrence. They should be taped together by means of cellulose tape in the manner prescribed, and the leads soldered to the detachable slide clips with which these particular batteries are fitted. As with *all* leads in radio control equipment, merely soldering the bared end of the wire is not sufficient. Twist the leads from both H/T and L/T batteries together to form one cable and anchor the cable securely to the batteries by means of the ever useful cellulose tape. NEVER allow a soldered joint to take the strain of a connection and you will avoid trouble.

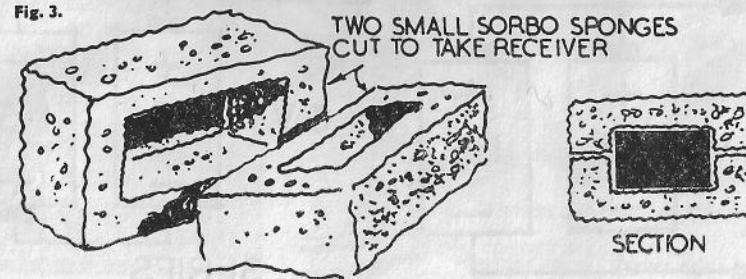
The battery most frequently in need of replacement is the $1\frac{1}{2}$ volt L/T cell; which must therefore have its connections arranged in a quickly detachable

Fig. 4.—A neat L/T battery arrangement. Note that the lead is bound to the clip and doubled back before making the soldered joint. The cell is, of course, stripped of its paper covering so as to make contact with the Terry clip.



manner. How this is done greatly depends on the type of L/T batteries used. With a large model, for instance, either a D.18 or a D.19 may be used. These particular batteries have built-in sockets, which facilitate the use of a standard two-pin plug. By virtue of their size they can also be relied upon to last many flying hours. With smaller models, either two Pen cells in parallel, or a U.2 are the answer. With this latter battery a neat arrangement can be fabricated using a Terry clip and a valve cap from a normal radio valve, see Fig. 4. A similar arrangement can also be made for the Pen cells, using smaller clips and caps, which can be wired in parallel where required. This wiring in parallel business may puzzle the uninitiated, but simply means that two $1\frac{1}{2}$ volt batteries are connected together negative to negative, and positive to positive, so as to still give $1\frac{1}{2}$ volts, but more amperes, and in turn, longer life. Fig. 5. A single Pen cell should not be used unless necessary for ultra lightweight purposes, and in this event should be checked frequently for voltage drop under load.

Fig. 3.



Another well used method of making battery connections is by means of snap fasteners. Unless these are employed in the proper way they can, however, be potential causes of radio failure. Fig. 16 Chapter IX describing the 'Acro-modeller' Receiver shows how the female portion of a size two Newey Snap Fastener is soldered to a 6BA tag, with the connecting lead soldered to the tag and the wire supported by a length of fuel tubing. The male portion of the snap fastener is soldered direct to the battery terminal, care being taken that no solder adheres to the pip on the fastener, otherwise it will not "pop" into the clip in its counterpart. The need for ensuring that every single connection is properly made, cannot be over emphasised. One bad contact will reduce hours of work to matchwood!

Wherever the receiver is mounted it is essential that the tuning control can be reached easily. On large models a proper door can be fitted in the side of the fuselage through which access can be gained to the tuning control. On smaller models a hole in the side of the fuselage large enough to admit a tuning key can be made coincidental with the position of the tuning control.

Study Figure 8 for a moment which is a diagrammatic wiring layout in a typical fuselage. Most commercial receivers these days have a four pin plug fitted to the various leads, or in some cases a three

pin and a two pin according to the demands of the particular receiver. Our task as far as installation within the fuselage is to run connections from corresponding sockets via switches, to the batteries and the actuator. With the receiver fitted in this way, it is then possible to remove it from the model without unsoldering leads and if the moneyed types who own more than one receiver take note to wire *all* their sets to their respective plugs in the same way, they then have an interchangeable hook up.

The aerial connection, you will note, is left on its own and the aerial lead from the receiver can either be made via a single plug and socket, by means of a 6BA bolt, or simply passed through a small hole in the side of the fuselage. If you adopt the latter scheme you must, however, knot the aerial on the inside of the hole. If this simple precaution is taken then the first time a "helper" has his foot on the aerial lead when you pick the model up the then resultant tug will not pull it out at the roots!

The aerial lead should run from the set to the top of the fuselage well clear of other leads, in this position it is also well away from the hand when holding the fuselage during tuning operations. From the exit point the aerial proper should then run to the top of the fin, any excess then trails at the rear of the aircraft. One of the reasons for securing the

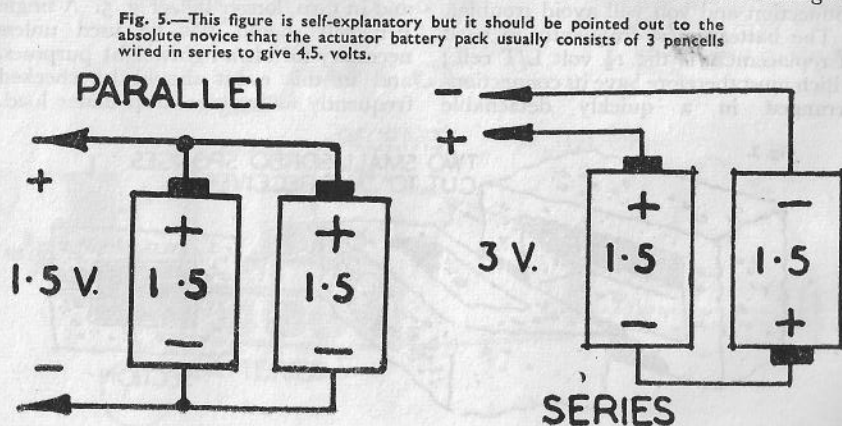


Fig. 5.—This figure is self-explanatory but it should be pointed out to the absolute novice that the actuator battery pack usually consists of 3 pen cells wired in series to give 4.5. volts.

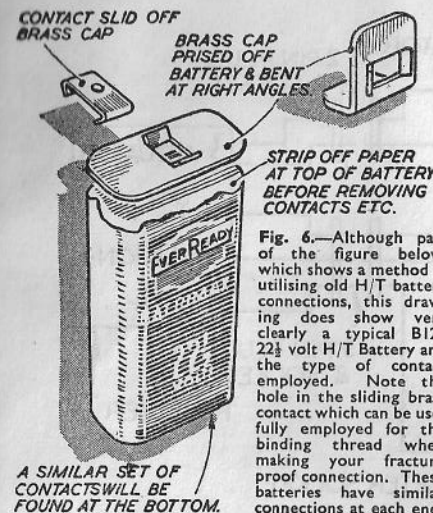


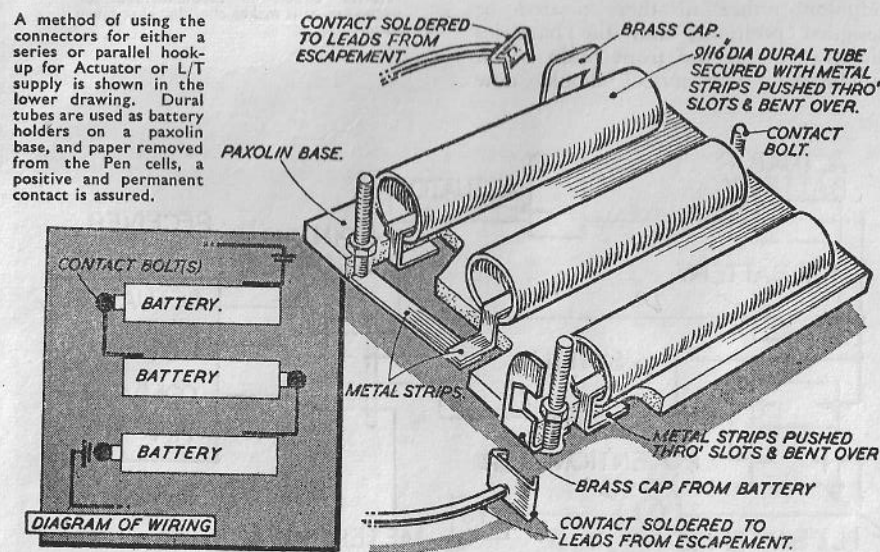
Fig. 6.—Although part of the figure below, which shows a method of utilising old H/T battery connections, this drawing does show very clearly a typical B122 22½ volt H/T Battery and the type of contact employed. Note the hole in the sliding brass contact which can be usefully employed for the binding thread when making your fracture proof connection. These batteries have similar connections at each end.

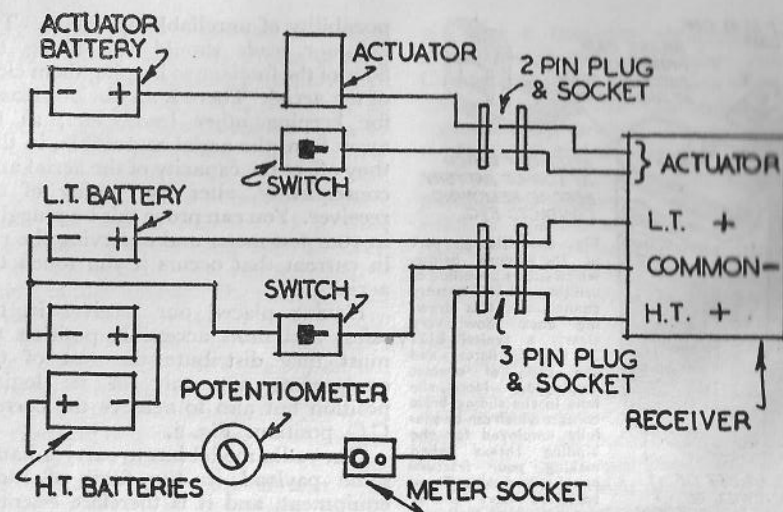
aerial at this point is to ensure that it does not foul the rudder crank, and jam it in either the left or right position. With some hard valve sets it is important that the minimum amount of aerial is left trailing, as this tends to induce a fluctuating standing current, with the

possibility of unreliable operation. The actuator leads should run along the floor of the fuselage so keeping them clear of the aerial. There is an obvious reason for keeping other leads, etc., as far away from the aerial as possible, in that they affect the capacity of the aerial and, consequently, alter the tuning of the receiver. You can prove this by plugging in your test meter and observing the rise in current that occurs if you touch the aerial.

Having placed our receiver in the safest and most accessible position we must now distribute the rest of the equipment, not only in its logical position but also to achieve the correct C.G. position. Fig. 2.

Our radio model has to carry a handsome payload in the form of radio equipment, and it is therefore essential to balance the model at its correct centre of gravity without adding ballast, i.e. by correct positioning of batteries and escapement. There is a simple method of achieving this. Complete the wings, tail and rudder right to the covering stage, but only take the fuselage to the completion of its structure. Should the fuselage be sheet covered, as is highly





probable with a radio control model, then the sheeting should be completed apart from the particular face of the fuselage through which the actuator is inserted. Make sure the fuselage really is completely assembled, with engine, tank, prop., undercarriage, wheels, etc., all in position. Then place the receiver and actuator, either in their desired or designed positions, and the batteries directly behind the front main cabin bulkhead. The model should now

Fig. 7.—Above and below are diagrammatic wiring circuits for typical receivers. The 3-pin and 2-pin set-up is specified for the E.C.C. 951A hard valve receiver, where a common negative for actuator and receiver circuit is not recommended. The use of separate switches for actuator and receiver circuit is recommended for beginners, as it makes checking that much easier.

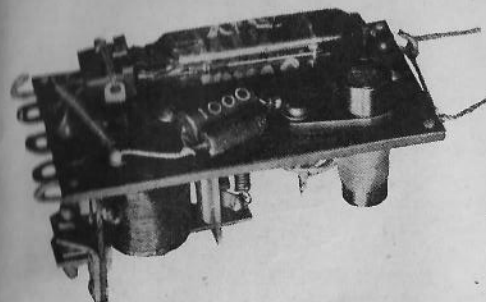
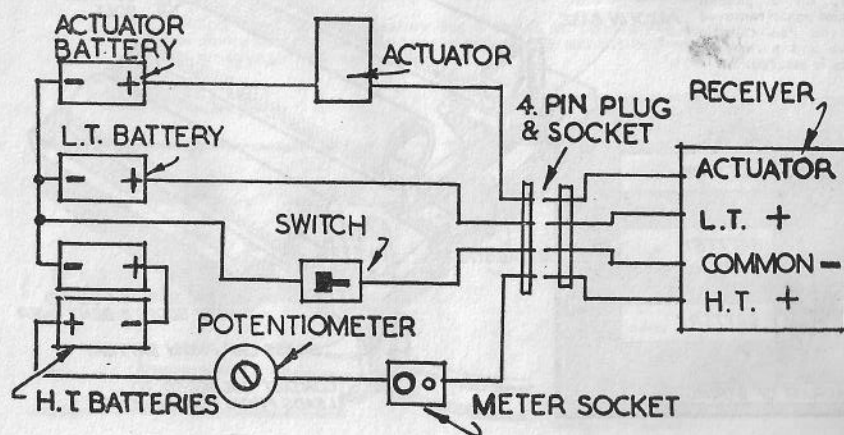
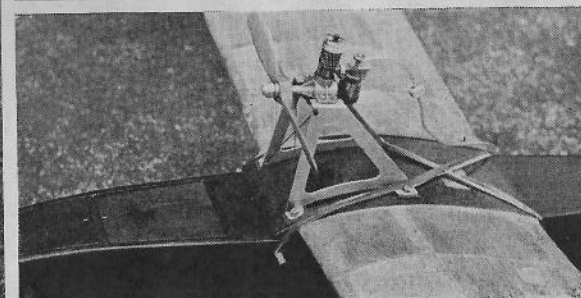
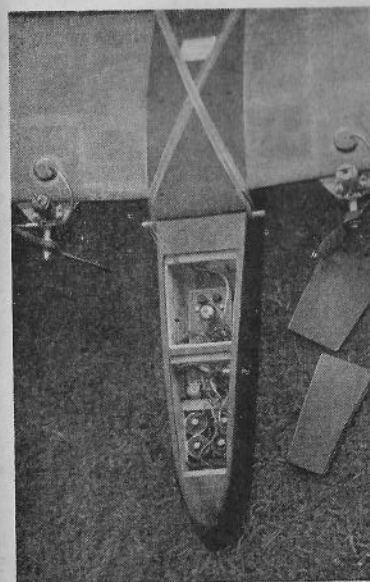
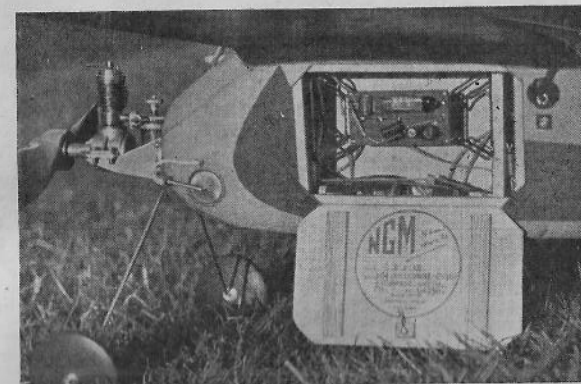


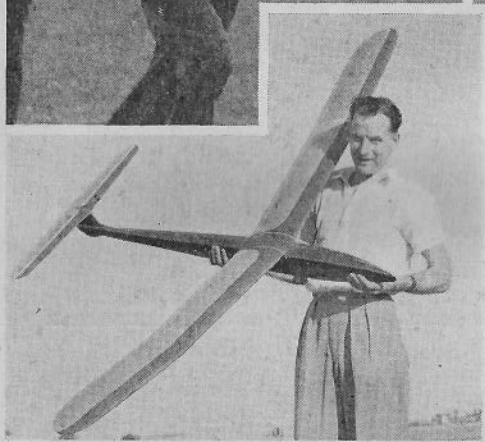
Photo above shows Geof. Pike's miniature receiver actual size. On the right we see Geof. himself with the diminutive Amco .87 powered model in which the receiver was used. Close-up shows the method of installing the receiver, which is suspended by rubber bands at the front, and thin cord at the rear. Cord for the rear anchorage prevents the receiver flying forwards in a heavy landing and hitting the front bulkhead.



Below, centre, is the "Sparky" model used by the author for a television programme—hence the somewhat elaborate decor. Bottom right, is a close-up of the motor mount used by Geof. Pike on the model with which he established a World Record in 1954. An existing glider can quickly be converted for radio controlled power flight by a simple mount such as this.

Below is another Pike variant, this time a twin using the same model. Note the radio and battery installation in the ample fuselage of the glider. Also the sorbo rubber shock pad in front of the batteries.

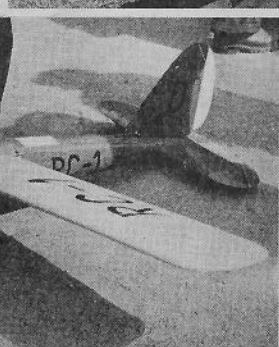
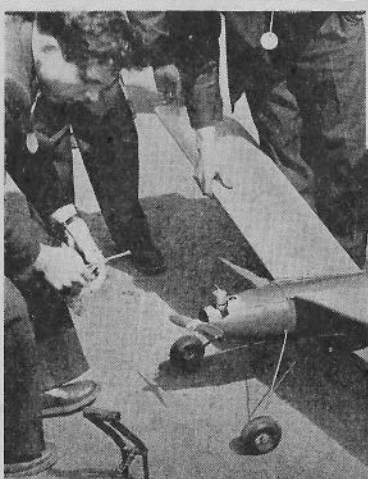
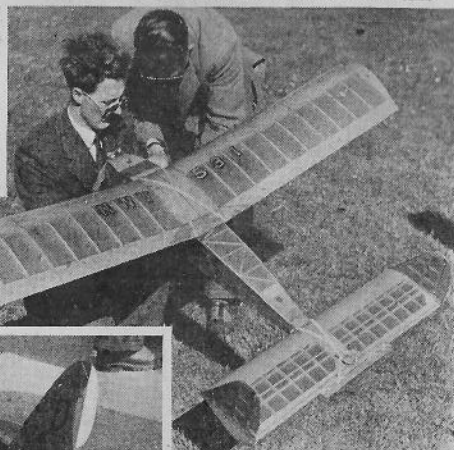




Above, A. Wastable of France with a very attractive own design model adjusts his motor during an international competition. Note the use of an old typewriter case to house the transmitter. Top left, Trevor Ware of the R.A.F. launches his beautiful radio controlled Mercury Aeronca Sedan.

Left, Frank Bethwaite of New Zealand with the radio controlled sailplane with which he established a World Record in 1954.

Below, an interesting twin finned model designed by Bill Verney which is powered with an E.D. 2.46 c.c. Racer, and controlled



by an E.D. 3 Reed Outfit.

Left, we have Herr Stegmaier of Germany with his famous R.C.I. This model uses a unique pneumatic system of control operation, worked from a bleed valve in the engine crankcase. The model is fully aerobatic even to the extent of inverted flight, and incorporates rudder, elevator, and two-speed engine control.

PLATE VI

INSTALLATION

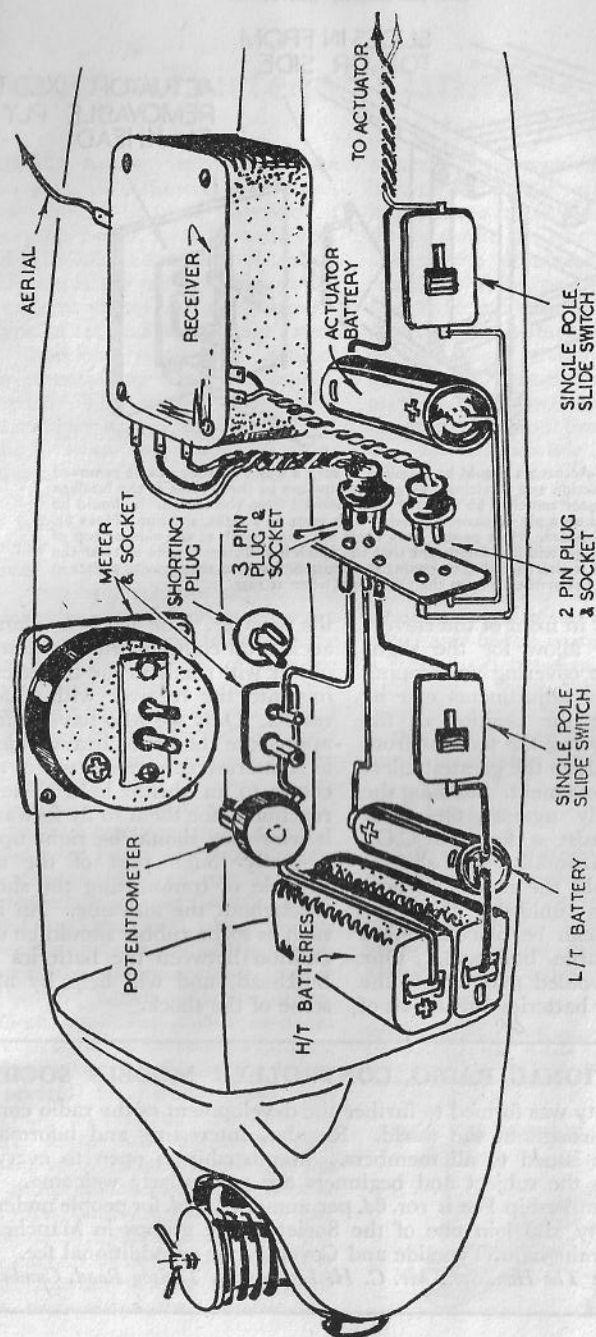


Fig. 8.—A schematic layout in a fuselage for the guidance of the beginner. It is emphasised that the actuator battery or batteries would normally be made up in a battery pack, together with the H/T and L/T supplies. They are only shown separately here to avoid confusion in the drawing. The shorting plug is best tied to a convenient point on the structure with a short length of twine, to prevent it being mislaid when not in use.

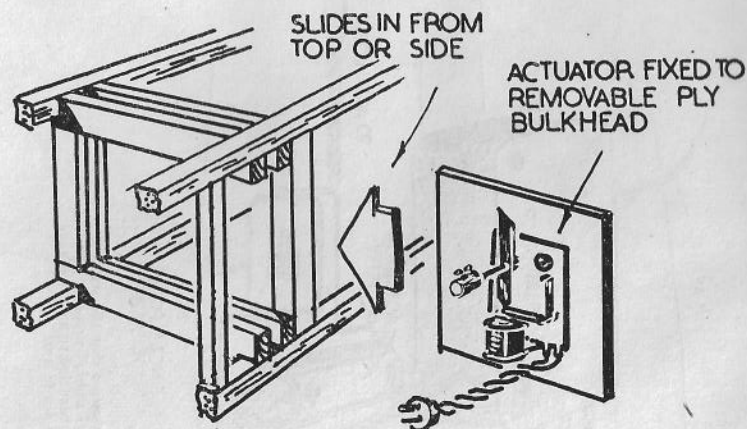


Fig. 9.—Actuators should be installed in such a way that they can be removed for inspection and servicing. By glueing runners to three sides of the fuselage the actuator can then be inserted and removed from the fourth. It should be mounted on a ply or paxolin panel, which must be a tight, and not a loose fit, in the runners. Most people have their inserting hatch at the side or top of the fuselage, and it is important that the hatch is sufficiently wide to clear the shaft. It is also advisable to mount the actuator itself so that gravity assists in keeping the armature from the pole piece when at rest.

balance a fraction in front of the correct C.G. position to allow for the slight rearward shift the covering and doping will impart. Any adjustments can be made by shifting the position of the actuator, which being the farthest from the C.G. will produce the greatest effect for the smallest movement. Stacking the batteries vertically against the front bulkhead will assist a forward C.G., laying them horizontally will shift it rearwards. Should the model be nose heavy, which is unlikely, then the actuator battery can be placed behind the rear main cabin bulkhead. One thing must be avoided and that is the positioning of any batteries directly aft of

the receiver. The first heavy landing, or accidental collision with an immovable object will result in the batteries smashing into the receiver with unfortunate results. Only we who have suffered can appreciate the havoc heavy objects such as batteries can cause when a model comes to an abrupt halt. The natural reaction is for them to fly forwards, that is why they should be right up against a really tough part of the structure capable of transmitting the shock load throughout the airframe. An insulator such as sorbo rubber should be used as a cushion between the batteries and the bulkhead, and will help by absorbing some of the shock.

INTERNATIONAL RADIO CONTROLLED MODELS SOCIETY

This Society was formed to further the development of the radio control of models throughout the world. Regular, interesting and informative bulletins are issued to all members. Membership is open to everyone interested in the subject and beginners are particularly welcome. The Country Membership Fee is 10s. 6d. per annum, 5s. 3d. for people under 21. Members may also join one of the Society's five groups in Manchester, London, Birmingham, Tyneside and Coventry for an additional fee. Details from: *The Hon. Sec., Mr. C. H. Lindsey, 55 Tenison Road, Cambridge.*

Chapter Thirteen Tuning

DETAILED tuning instructions are given with all commercial receivers and these should be read carefully if satisfactory operation is to be achieved. In broad principle the method of tuning most receivers is the same, although the various current values will vary according to type of set and the voltage used. Let us therefore cover the subject generally, mentioning firstly the equipment needed. This consists of our ever useful test meter and a suitable tuning key, which must be made of non-conductive material. On no account use a metal screwdriver as this will prevent accurate tuning. Switch on the receiver and observe your meter when a metal screwdriver is placed near the tuning control. You will see the needle rise even before the screwdriver touches the control, and if your hand is contacting the metal the effect will be even more pronounced. Tuning keys should *always* be made from a non-conductive material such as Perspex or Paxolin rod, the ends of which can be easily shaped to the desired section. An ordinary chisel section will do for most controls but where a beehive type condenser is used a key shaped as in Fig. 1 will be necessary.

It is a good idea to run through tuning procedure on the bench before going out on the field, but always remember that adjustment of the tuning control at range is more accurate than it will be on the bench with the transmitter close by. For this reason do not erect the aerial when bench tuning so as to reduce power, and keep the transmitter several feet away from the receiver. On no account tune with the transmitter aerial fully assembled and close to the receiver as this swamps the receiver and produces misleading effects.

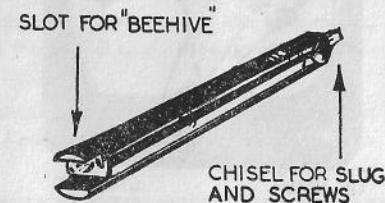
Check first that you have the right length of receiver aerial, and that the standing current as per meter is what it should be for the voltage being used. Key the transmitter and observe the

meter. If the receiver is anywhere near in tune the needle will swing to the left indicating a current drop, and you must slowly rotate the tuning control so as to obtain the maximum drop or lowest reading. Rotating the control you will find that the needle goes to its lowest point and then starts to rise again as you go past the "in-tune" position. It is then merely a case of reversing direction on the control two or three times so as to be really satisfied that you have found the lowest possible current reading. This reading is given for most commercial receivers, and should it be found that the reading specified cannot be obtained to within .2 ma, then probably the aerial length is incorrect or the receiver is being too heavily loaded. The insertion of a variable trimming condenser in the aerial will correct this, a value of between 5-30 pfd being sufficient. This "loading" effect is most likely to occur with model boats, or with aircraft when they are being tuned under very damp conditions.

Relay Setting

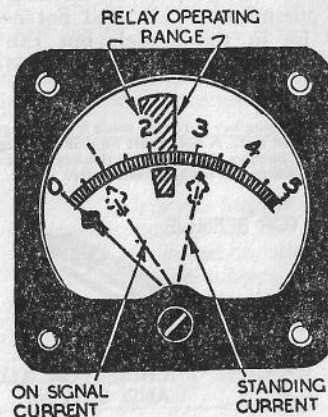
The author includes a potentiometer or variable resistance in his receiver circuit for the purpose of checking the relay operation. This need not necessarily be in the model, but can be attached or included in the Test Meter

FIG. 1.—A tuning key is quickly made from a length of $\frac{1}{4}$ or $\frac{3}{8}$ Paxolin rod. A hole must be drilled along the rod at the "beehive" end, so that the key drops over the centre pin of the beehive condenser.



and wired in series with it. For XFG 1 receivers a value of 5,000 ohm is sufficient, but higher values will be necessary for hard valve receivers according to the H/T voltage used. A 50K potentiometer will cover most needs. By adjustment of the potentiometer we can drop the standing current to zero if necessary and so check our relay operation. The manufacturers will specify the operating figures for both Relay IN and Relay OUT. Study Fig. 2 for a moment, which shows diagrammatically the settings for a hypothetical receiver. Standing current is 3 milliamps, dropping to .9 milliamps on receipt of a signal when correctly tuned. Slowly rotate the potentiometer which will swing the pointer on the meter towards zero. At a reading of 2 milliamps you should hear a click as the relay drops out, in other words the current through the relay coils has been lowered to the point where the magnetic core can no longer hold the armature against the tension of the return spring. Take the current to zero and then rotate your potentiometer in the reverse direction and very slowly raise the current. Assuming that the relay fell out at the correct current reading you will then find that you go past this reading of 2 milliamps and that the relay clicks in at 2.4 milliamps. The area between 2 milliamps and 2.4 milliamps is

FIG. 2.



therefore the operating range of our relay. The difference between these two readings in relation to the cut-in figure is known as the In-Out ratio.

Hard Valve Receivers

Most hard valve receivers have two tuning controls, the *primary* consists of a slug that screws within the aerial coil former, and the *secondary* control which can take various forms according to the type of receiver. It can be a potentiometer in the case of the Ivy, a beehive condenser in the Aeromodeller No. 1, and a slug within the quench coils in the E.C.C. 951A and E.D. Boomerang.

In all the above cases the secondary control adjusts the sensitivity of the receiver and great care should be taken to ensure that the correct tuning procedure is adhered to. With most hard valve receivers one should tune for maximum drop by means of both controls and then the secondary control should be unscrewed at least a full turn, otherwise the set will be over sensitive. This readjustment of the secondary will invariably mean a slight sacrifice in current drop, usually from .5ma to .7ma approximately, but this matters little as the figure is still well below the relay operating point. Over sensitivity is usually disclosed by a wavering standing current and often by the rudder wagging furiously once the model has climbed away from ground capacity.

X.F.G.1. Receivers

Tuning X.F.G.1. receivers is not quite so straightforward to describe as characteristics vary between valves and change as the individual valve ages. H/T voltage with this valve must not exceed 45 volts and at this figure it will be found that the standing current can be between two and three milliamps approximately, according to the characteristics of the particular valve in use. On no account should the receiver be operated at its maximum otherwise the valve life will be shortened. Standing current should be maintained at 1.6 ma by means of a potentiometer and it will

be found necessary to advance the control as the valve ages in order to maintain the current. The E.D. Boomerang is the only commercial set using an X.F.G.1. at the present time, and the manufacturers have provided no fewer than five aerial tags to accommodate varying valve characteristics. Valves giving a high standard current when new should be operated with a short aerial, and in some cases with no aerial at all until they are "run-in" otherwise it may be difficult to obtain the requisite current drop. They are, however, the exception rather than the rule, for the big advantage of the X.F.G.1. set is the fact that the current drops to virtually nil on receipt of a signal. On homemade sets considerable adjustment can be made by altering the length of the aerial, which on the average set should be about 40 inches long. Adjustment can also be effected by inserting a 30 pf trimming condenser in the aerial lead. With one particular valve the author eventually reached an aerial length of 5 feet at which length the set operated for almost two seasons. Incidentally, with an X.F.G.1. set, a sign that the aerial length is insufficient is a wavering standing current, the same effect also being apparent when the L/T batteries are getting low. Once one is fully acquainted with the eccentricities of the valve, tuning is quite straightforward and the



FIG. 3.—Simplest method of adapting the ordinary 0.5 millimeter is by means of two short lengths of 14 gauge tinned copper wire. The ends are soldered directly into a two pin polarised plug, the rigidity of the wire being sufficient to keep the meter in position.

normal procedure as described earlier should be carried out.

A table is given below showing approximate settings for both X.F.G.1. and Hard Valve receivers. It should be remembered that current changes vary slightly, depending on the condition of the batteries, and that with hard valve receivers the higher the voltage used the greater the sensitivity.

Operating Voltage	Top Current m/a	Current on Receipt of Signal m/a	Relay IN m/a	Relay OUT m/a
45	1.6	0.2	1.2	0.9
60	2.8	0.5	2.2	1.8
67½	3.2	0.7	2.4	2.0
72	3.6	0.7	2.8	2.4
90	5.0	0.8	3.5	3.0

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Chapter Fourteen

Pre-flight Preparation

HAVING checked our radio equipment both on the bench and after installation in the fuselage we must now prepare the model for its first flight tests. With all flying surfaces fully rigged, place the model on a table and check at eye level that wings, tailplane, fin and rudder, undercarriage, wheels, etc., are all in correct alignment. This is most important as warped or badly rigged flying surfaces will prevent the dead straight flight path we wish to achieve. Now it is time to check the C.G. or centre of gravity. The position of this is invariably marked on the plan you are building from, and with radio control models it is usually a little further forward than normal, i.e. about 25 per cent. to 33 per cent. of the cord from the leading edge. Place a finger each side of the fuselage coinciding with the C.G. position and near the wing root, then gently lift the model by your finger tips. It should, of course, balance in a horizontal attitude, and in the event of the nose dipping, then the centre of gravity is too far forward, and if the reverse happens then it is too far back. If you have followed the advice given in Chapter XII only slight adjustment will be necessary.

Do not forget the line up of the motor. If downthrust is specified, make sure you have the correct amount, also any sidethrust. Unless you are particularly lucky it is probable that some adjustment to this latter item will be necessary, after you have studied the flight pattern of your first radio control solo. With this in mind make sure that provision is made for the necessary amount of adjustment to the motor. Allied to this same subject is the effect a change in propeller will have on a model. The author has found that with a model trimmed for straight flight with one prop, that a substitution will give a pronounced turn to the right, and that yet another will turn the model

to the left! Moral is, always trim with the particular propeller you intend using. However, let us not rush on to flight trimming as there are still other important ground checks to be made.

Warm up your Motor

So many people get into trouble through failing to test their motor thoroughly **before** going to the flying field. Make sure it starts easily and fully acquaint yourself with the control settings. Make certain it will run a tank out and while it is doing this check the operation of the radio just in case the engine vibration discloses any bad connections or more serious faults such as relay chatter.

A word of warning at this juncture would not go amiss—Should your rudder waggle furiously under the influence of engine vibration do not leap into immediate battle with the relay as this may be a perfectly innocent party. Firstly read Chapter XVI on fault finding. However, mentioning fault-finding at this stage is a little pessimistic, and providing reasonable care is taken, most readers will not need to re-read that particular chapter very often.

Test Gliding

We have now reached the stage where we might start sniffing the weather and looking for a suitable day for test gliding and our first radio control flight. Most people are naturally impatient for this moment, but it really is worth waiting for a reasonably calm day. With most radio models the wing loading is fairly high, so that a dead calm is undesirable. A light breeze makes the somewhat terrifying experience of test gliding a deal easier by removing the necessity of hurling the model like a javelin. Even experienced modellers may feel

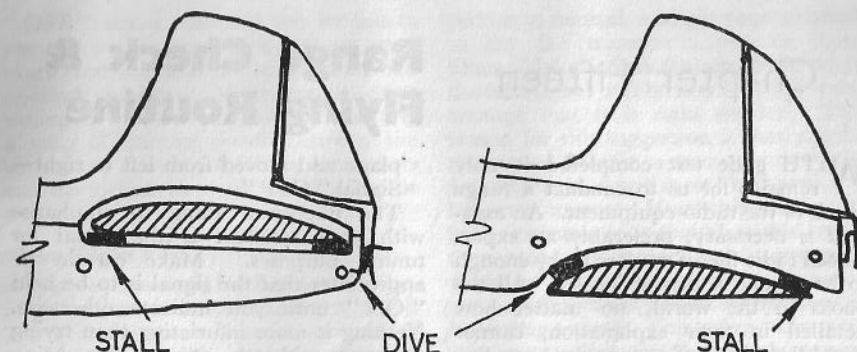


FIG. 1.—This figure illustrates the basic method of trimming for correct glide by means of balsa packing. Add, at the most, only $\frac{1}{8}$ at a time, and cement the packing in position when the desired trim is obtained. With radio models one should err slightly on the side of under elevation rather than the reverse.

a little trepidation at hand gliding their first radio model. For a start it feels a little weighty and one cannot help thinking of the cost of the radio gear and all the hours of work that have gone into the airframe. It is, however, fatal to adopt a half-hearted attitude with test gliding. If the model is correctly rigged and the C.G. position where it should be, then all that is necessary is to launch the model into wind at its correct flying speed. The author runs with the model and "feels" it into the air, for it is a fact that most models will fly themselves out of your hand if you run at the right speed. Airborne equipment should show no tendency to shift even after one or two bouncy landings. If it does, then put

matters right immediately. Anything that moves will do damage, and conditions within the fuselage should be such that even a landing capable of wiping off the undercarriage should leave everything inside the fuselage intact.

Glide trim should be adjusted by means of packing under the tailplane. If the model stalls then pack under the leading edge. If it dives, then pack under the trailing edge. Fig. 1. Add only a $\frac{1}{8}$ at a time and cement the packing in place once a satisfactory glide has been achieved. Check also that the model glides straight and remember to do this with the rudder crank in both of its neutral positions in case the crank is out of adjustment.

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Chapter Fifteen

Range Check & Flying Routine

WITH glide test completed it only remains for us to conduct a range check of the radio equipment. An assistant is necessary, preferably an experienced radio flier if you are lucky enough to have such a person locally. All the books in the world, no matter how detailed in their explanation, cannot equal the advice of a man who has a few years experience at the game. However, if you are unlucky in this respect—carefully brief the wife or friend. Station him or her at the transmitter, firstly arranging a clear system of hand signals (Fig. 1).

The author uses the following scheme: Arm raised vertically above head and lowered—Signal "ON" for half a second and then "OFF".

Arm raised vertically above head and rotated—Signal "ON" and held "ON" for tuning until "OFF" signal is given.

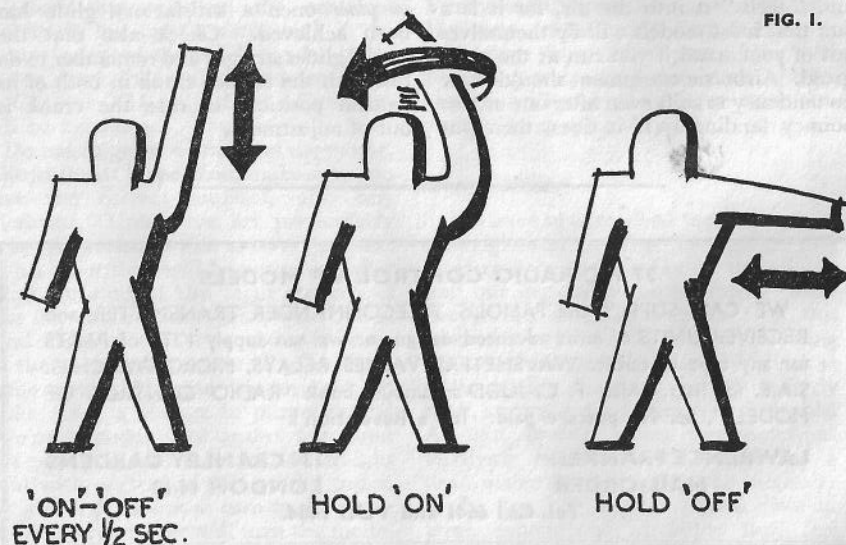
Arm fully extended in horizontal

plane and moved from left to right—Signal "OFF".

The important thing to emphasise with your assistant is the signal for tuning purposes. Make certain he appreciates that the signal is to be held "ON" until you indicate otherwise. Nothing is more infuriating than trying to tune with the transmitter being keyed at half second intervals!

Firstly do a check at about 10 yards range with the invaluable millimeter plugged in, then walk at least 300 to 400 yards away and re-check the tuning. At this distance on the ground you may not get the same current drop as at close range, but this does not matter providing the "drop" reading is well below your relay "out" figure. Now remove the meter and insert the shorting plug, then check operation once again. Whilst you are walking the three to four hundred yards switch on the set at say 50 yard intervals and give the "ON"—

FIG. 1.



"OFF" signal. Should the set fail to respond before you reach the 400 yard mark then you must insert the meter and re-check tuning. Make certain your tuning control will not shift by inserting a wisp of darning wool between the threads of the slug, beehive condensers can be locked by a dab of Shellac or cement.

First Flight!

Now we are ready for that never-to-be-forgotten moment—our first test flight. There is always a certain amount of tension present on this rather momentous occasion, so let us plan the routine in advance. A routine that should be strictly maintained for all future flights if trouble is to be avoided.

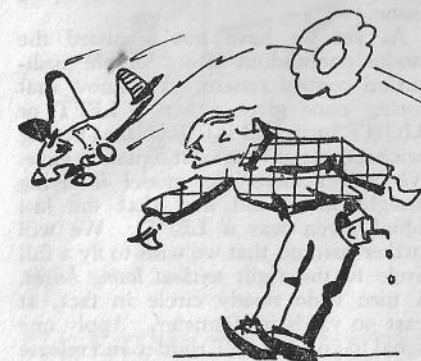
Firstly put at least 100 turns on the escapement motor, and then tank up with sufficient fuel for an engine run of 2 minutes. Start the motor, and let it warm up, remembering that with most diesels it will be necessary to decrease the compression slightly once the motor is hot, otherwise it will almost certainly tighten up and possibly stop in the air. Switch on your actuator circuit first and observe that the rudder stays firmly over to either left or right. Switch on the receiver circuit, which will bring the

rudder to neutral, and get your assistant to key the transmitter two or three times. Make certain that you know what the next signal will be and for preference arrange that it is right rudder. The reason for this suggestion is that should the model fly with a turn, then on this first test flight, it will most likely be to the left with torque. If anything does not behave exactly as it should at this stage, then stop the motor and investigate.

Under no circumstances attempt to fly unless you are fully satisfied that all the equipment is functioning perfectly. This policy cannot be over emphasised for the simple reason that so many people in the excitement of their first flight are prone to fling the model in the air regardless. Just remember that the model and equipment cost you at least £10 before you do anything silly. However, let us return to the flight.

It is better to let your assistant launch, so that you have control of the model from the moment it leaves his hands. Make certain he knows how to launch correctly, running until the model flies itself from his grasp on a nice even keel. You may not, of course, have the assistance of an experienced helper, or you may prefer to launch yourself, in which case, go ahead. Remember,

FIG. 2.—The right, and wrong way to launch a radio model! The wrong way can also take the form of an upward javelin throw, the ending is much the same in each case! Technique for a successful launch is to run as near to flying speed of model as is possible, and let it fly out of your hand.



however, to launch in the manner prescribed, and even more important, launch *into wind*. Whilst mentioning wind, for heaven's sake pick a moderately calm day for this first test flight. It need not be a flat calm as a light breeze makes it easier to get the somewhat heavily loaded radio model into the air.

Well there we are, with our model climbing steadily away, possibly in a gentle turn to the left, and beads of perspiration on our anxious brow. What's the next move? Our itching thumb says "Press the button". However, resist this impulse and let the model gain some height. Now give a short signal and watch the effect on the model. The nose will immediately swing to the right, and observe how it continues turning to the right for quite a few seconds after you release the button. This is one of the most important lessons of radio control pilotage. You must learn to judge and allow for the continuing turn effect imparted to the model *after* you have released the control.

Another important first principle of radio control flying is that the model should be flown up wind before any manoeuvres are attempted. So steer the model giving gentle LEFT and RIGHT signals if necessary, until it is at least 150 to 200 yards up wind of the transmitter. *Do not over control*. Most of the time the model should be flying itself with only occasional touches of the button to keep it on course. Over controlling is a fault that most people suffer from in their "trainee" flying stage.

The reason we go well up wind before attempting manoeuvres is fairly obvious, inasmuch that each successive manoeuvre will take the model further down wind owing to drift, and an inexperienced flier may well give the wrong signal at the right moment, ending up so far down wind of his transmitter that he is not at all sure which direction the model is flying anyway.

Let us not forget that this first flight is not only *your* first solo but also the first *test* flight of the model itself. Imagine a trainee R.A.F. pilot being given his

first solo in a new and untried aircraft and you will appreciate the need for caution. There are three things we must watch and mentally note in relation to the trim of the model.

Firstly, is it power stalling? i.e. climbing too steeply and falling away, or did it after launching refuse to climb and descend to terra firma with the motor running?

Secondly, does it fly on a dead straight course into wind or does it persist in turning to either left or right?

Thirdly, what happens when the motor cuts? Has it a natural turn to either left or right on the glide? We will assume that it is neither under or over elevated on the glide as we previously checked the glide trim before our flight under power.

If the glide is O.K. then it is a simple matter to correct either under or over elevation under power by applying either upthrust or downthrust to the motor. Similarly right or left turn under power can be counteracted by altering the engine thrust to left or right. In this respect remember that a change in propeller can make a model that normally turns in one direction, turn equally as much the opposite way. Torque is supposedly constant, so the author concludes the difference is due to a change in gyroscopic effect imparted by different propellers.

However, let us return to the juncture where our model is up wind some 150 yards, and carry on with our first flying lesson.

As yet we have not discussed the modus operandum of our simple push-button control system. We know that keying once gives either a LEFT or RIGHT turn, and it follows that keying twice returns us to the last signal we gave. We will assume the model is flying straight into wind and that the last signal given was a LEFT. We will further assume that we wish to fly a full circle to the right *without losing height*. A nice wide steady circle in fact, at least 50 yards in diameter. Apply one signal to give RIGHT rudder and release immediately the nose swings and the

right wing drops in a bank. The model will go on turning right remember for a few seconds and we must be ready to give *two* signals so as to be able to apply RIGHT rudder again before the model has time to straighten itself. We actually pass through LEFT rudder position so quickly that it has no effect on the flight path whatsoever. Your first efforts at making wide turns by this method will probably be a little ragged but practice and experience will soon produce smooth evenly banked turns that are a pleasure to watch. Take off the RIGHT signals several degrees before you are round into wind again, and leave the model to complete the last segment of the circle on its own. You can now try a wide left turn on the same principle, remembering to fly upwind a sufficient distance to compensate for the distance lost through drift on your first turn.

But what's this? The engine has cut! However, not to worry. We must now prepare for our glide path and landing. The model is nicely up wind and at a height of approximately 200 feet. We

apply rudder to give a gentle turn and then let her fly overhead downwind with the control at neutral. The beauty of our self-neutralising escapement is, as the name suggests, the fact that no signal gives NEUTRAL rudder, so that any time we get flummoxed we merely leave the button alone, confident in the thought that the model will end up flying straight and level.

Let the model reach a point some 100 yards downwind of you and then apply rudder until she is flying upwind towards the transmitter. It will be immediately apparent that your amount of control has been considerably reduced. In fact, you will find it necessary to make this turn into wind by holding a signal for what appears an abnormal length of time. The reason being that the slipstream from the propeller is no longer accentuating the effect of the rudder. You will in all probability think that the radio is not working when applying the first glide turn. It seems ages before the nose begins to swing in the desired direction, so do not make the usual

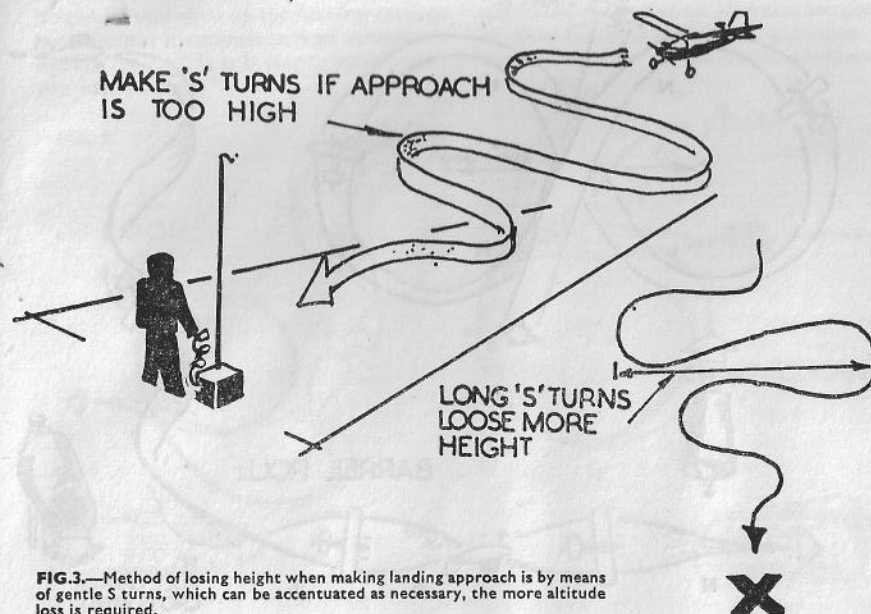


FIG.3.—Method of losing height when making landing approach is by means of gentle S turns, which can be accentuated as necessary, the more altitude loss is required.

mistake of keying again, thinking you skipped a signal, otherwise you will end up turning the wrong way.

Our model at this juncture appears much too high and you will be convinced that it will overshoot. This is how it should be, and we lose height by making a series of S turns to a pattern as in Fig. 3, taking off the last of the turns when the model is some 20 feet up. All that now remains is to keep the nose dead into wind with perhaps a gentle touch of rudder when necessary. Do not worry about spot landing at this stage. Concentrate on landing into wind on a nice even keel, never mind whether you are anywhere near the transmitter. Accuracy of landing at a desired spot will come with extensive practice, your prime purpose at the moment is to learn to fly in a steady and sedate fashion.

By now, your assistant should be alongside the model switching off the set to conserve battery life, and you are ready for the next flight. Or are you?

On this particular occasion there will almost certainly be trimming adjustments to be made, and on *all* occasions there is our check routine to be carried out before the model can be airborne again. In full size flying a pilot never leaves the ground until he has carried out his routine cockpit drill, so if you wish to enjoy successful and prolonged radio flying, then follow the full size principle. A lot of experienced fliers are going to say that a full check of equipment between each flight is unnecessary, but the author maintains that for 100 per cent. surety it is essential. Certainly all newcomers to the game would be well advised to do so until they have many months' experience behind them.

Cockpit Drill

1. Check flying surfaces, wing retaining bands, etc.
2. Wind escapement.
3. Check receiver with meter in

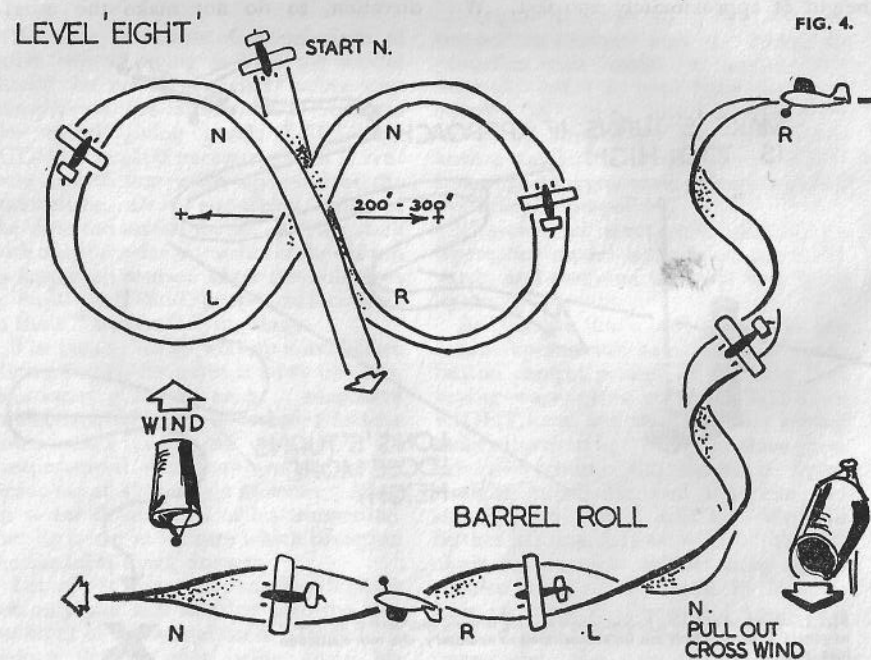


FIG. 4.

position, observing standing current drop when transmitter is keyed. Switch off, and replace meter with shorting plug.

4. Fuel up tank according to flight requirements.
5. Start engine and allow at least 30 seconds warming up time.
6. Get assistant to lift model from ground and switch on set.
7. Check operation with engine running, making sure assistant's hands are well clear of aerial. Give at least six signals and remember the direction of next rudder movement.

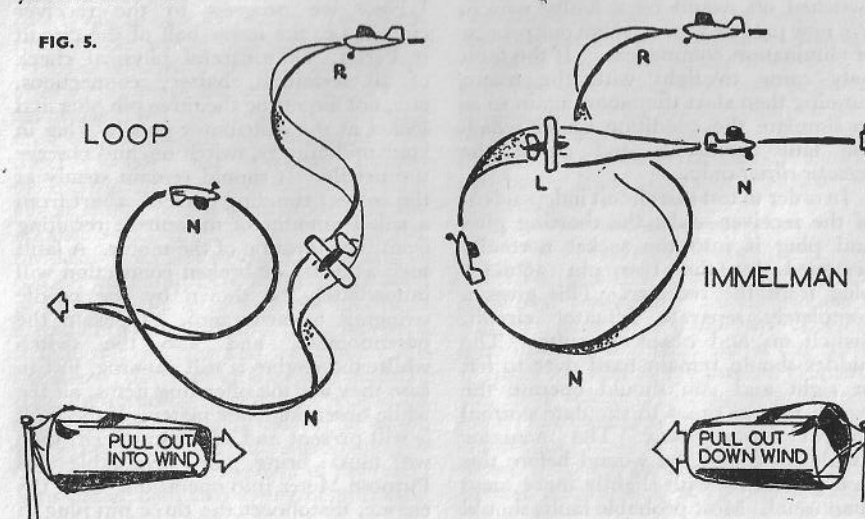
Returning to our flying once again—there is one unbreakable law that applies to full size aviation as well as model radio flying. *Never try and go round again.* In other words if you overshoot by coming in too high, on no account try another full turn unless you have at least 60 to 70 feet altitude. If you do, the model will almost certainly pile in on the down wind run.

You can, after several circuits and bumps, increase your tankage to 3 or 4 mins, and let the model gain more height. Be satisfied on the first few outings with simple manoeuvres, and remember the old motto "It is better to walk before you learn to run".

There is a technique in making progress upwind. It is to fly at approximately 30 degrees off wind in one direction, followed by 30 degrees off wind in the other direction. Rather on the lines of tacking a yacht into wind. If you have trouble in obtaining penetration then shift the C.G. farther forward.

You have now gained practice and confidence, and for this reason are a bigger menace to yourself and the model than you were on the first solo. Don't forget it! Try holding turns on a little longer (starting from a safe height of course), letting the model spiral downwards. Notice how quickly the turn tightens, and remember that important time lag after you release the button. Apply a little opposite rudder as the model comes out of the shallow spiral dive. Try and judge this so that the model zooms into wind, and then turn it off the power stall at the top of the zoom by a judicious touch of rudder. Make a note that the model spirals faster and quicker in one direction than it does in the other. This characteristic you can use to your advantage in certain aerobatic manoeuvres. Several are given in this Chapter for your guidance in the future, so go to it and—Happy Landings!

FIG. 5.



Chapter Sixteen

Fault Finding

LOGIC and plain common sense will track down even the trickiest of faults providing one goes about it in the right way. The principle of fault finding is *elimination*. One goes on eliminating various sections of the equipment and circuits until the faulty item comes to light.

Let us take for example "rudder wagging", the complaint most frequently encountered. There are three conditions under which this can take place:

1. Before either the escapement or the receiver have been switched on.
2. After they have been switched on and before the transmitter has been keyed.
3. After the transmitter has been keyed.

Starting with *Stage 1* the most probable cause is the actuator which may be skipping either through maladjustment or use of an incorrect sized rubber motor. The only other item likely to cause rudder movement with all circuits switched off would be a faulty switch. We now pass to *Stage 2* where our process of elimination commences. If the fault only came to light with the motor running then start the motor again so as to simulate the condition under which the fault occurred, and check the *actuator circuit* only.

In order to test this circuit independent of the receiver—take the shorting plug and plug it into the socket normally occupied by the two pin actuator plug from the receiver. This gives a completely separate actuator circuit. Switch on and observe results. The rudder should remain hard over to left or right and you should operate the switch several times to simulate normal control movement. The actuator should, of course, be wound before this test, preferably with slightly more turns than usual. Most probable faults should

the rudder misbehave at this stage are again maladjustment of the actuator, a faulty switch or wiring connection, or dud batteries. Fully satisfied that the actuator circuit is O.K. we now pass to the receiver circuit, not forgetting to check the actuator socket, plug and leads as far as the receiver panel. Remove the shorting plug and insert the normal two pin plug; switch on the escapement circuit only, and again observe results with the motor running. By doing this we have now added to our already checked actuator circuit one side of the relay contacts. It would be as well to study Fig. 7 on page 64 at this stage, which shows the wiring diagram and also Fig. 1 on page 17 showing the relay. It will be appreciated that should the rudder skip at this point of our test, then the armature is jumping away from contact "B" which indicates that there is insufficient tension on the relay return spring. Should this be so, it must be remembered that altering the tension will mean readjusting the relay.

Now we progress to the receiver circuit, i.e. the lower half of the circuit in Fig. 7. Do a careful physical check of all terminals, battery connections, etc., not forgetting the three pin plug and socket at the distributor panel. Plug in your milliammeter, switch on, and observe the needle. It should remain steady at the correct standing current, apart from a small amount of movement resulting from the vibration of the motor. A fault such as a dry or broken connection will immediately be shown by the needle swinging towards zero. Operate the potentiometer and also the switch whilst the engine is still running, just in case they are the offending items, all the while observing your meter. If the fault is still present and so far untraced, then we must bring our invaluable All Purpose Meter into operation. Stop the engine, disconnect the three pin plug at

the distributor panel and plug the negative probe of your meter into the negative terminal of the three pin socket. Check both the H/T circuit and L/T circuit, working from the socket towards the batteries. Check every component and finally check the voltage of the batteries *under load*. This, of course, means with the receiver connected and the circuit switched on. L/T batteries should be discarded if they read less than 1.4 volts and the H/T voltage should be such that the anode current reads at least .5 milliamps above the relay operating point.

We have now checked all circuits with the exception of the wiring of the receiver, and should the fault still be elusive, then the test meter must be used to systematically check the internal wiring. Firstly, run through the H/T circuit, being very careful not to short the H/T current onto the L/T circuit, otherwise you will be needing a new valve. Check continuity through the relay coil, quench coils and components like the H.F. Choke. Watch the valve itself to ascertain that the filaments are alight. In the case of the X.F.G.1., this is readily observed as a bright mauve blue glow, but with a hard valve the filament only shows as a thin, red hot wire that is not so easy to discern. Your local radio dealer will always check the valve on his tester should you have any doubts.

In *Stage Three* of our fault finding, we are assuming that the trouble is occurring after we have keyed the transmitter. In other words the rudder instead of staying in the position when first keyed, either jumps to neutral or to the opposite rudder position, or waggles furiously from left to right. We are, of course, assuming here that it does none of these things until a signal has been given. First and obvious thing to check is that the receiver and transmitter are in tune. If the receiver is slightly off tune, then the standing current on receipt of a signal may be dropping only as far as the relay operating current introducing a sort of half-in-half condition in the relay. This under influence of engine vibration causes the relay points to chatter madly,

thus wagging the rudder to and fro. Plugging the indispensable test meter in circuit will indicate this condition. Should the tuning be O.K. but the current as indicated by the meter dropping from full standing current to the normal dropped position, then we should suspect a fault in the transmitter. The author had persistent trouble at one time with rudder being applied at most disconcerting moments. Hours were spent examining the receiver, escapement etc., but the fault continued. Finally, it was noticed that the needle on the milliammeter built into the transmitter circuit jumped to the full load position when the keying lead was picked up *before* the keying switch was operated. Investigation showed that constant use of the lead had broken the insulation shorting the switch out and thus keying the transmitter when least desired. On another occasion a model was lost on a flyaway with once again everything but the transmitter being suspect. Eventually, it was noticed that the transmitter aerial socket was loose in the case thus cutting in and out the aerial from the circuit. Which all goes to prove that a visual means of checking that the transmitter is working is a very good thing. Fitting either a 0-50 milliammeter or polarised two-pin socket into the top of transmitter case is a simple job. The socket, like the meter, is connected in the positive H/T lead, and enables our Universal Meter to be plugged in, and the operating current of the transmitter observed. With the average transmitter, the current should rise under load to between 20 and 30 milliamps.

Author's Note

I have put this Chapter last in the hope you would-be "button-pushers" will not need it. When you do, just bear in mind that nine out of ten radio troubles are due to the human element, i.e., bad soldered joints, unsupported joints, flat batteries, etc. Examine your conscience well before you go anywhere near a flying field, and leave that blamed relay alone! It's probably something else.

Plate VII

Photographs opposite, left to right, from top to bottom, are as follows :

The E.D. "Boomerang" Hard Valve version which arrives wired and complete with switches, plugs, sockets and actuator. Another version using the X.F.G.I. valve is also available. The receiver in both examples is encased in plastic to protect the relay and other components. Note the slide switch which is the best type to use for positive and reliable contact.

Photographic illustration of the modification to the Siemens 73 Relay referred to on page 17 Chapter IV. This particular example is used by Ted Sills in a hard valve receiver of his own design, and gives very satisfactory results.

The Ivy Receiver—which uses a 1S4 valve is unusual in that it includes a potentiometer within the receiver circuit, and not as a separate item as with other receivers. Designed by Tommy Ives, it is a reliable set and incorporates its own relay.

A very bright idea for a receiver case, which is the brainchild of Fred Rising of Whissendine, uses a Gillette razor case with suitable holes drilled for the valve and tuning slug, etc. The case opens into two halves should one wish to get at the "works".

Installation of an E.C.C. 951A Receiver in a "Sparky" fuselage, features the sorbo sponge method described in Chapter XII, and uses rubber bands as an additional safeguard. Another sponge with the centre cut out fits on top of the receiver to protect the valve.

With the large tanks necessary for prolonged radio flights, it is essential to be able to see the fuel level. This close-up of a "Sparky" nose shows the small side windows and the fuel chamber hatch, which are made from Celastoid, which permits easy vision. The tank filler vent can be seen protruding through the hatch; note also the fuel lead to the motor, which is kept as short as possible, and deliberately taken outside the fuselage for two reasons. Firstly, to prevent kinks, and subsequent fuel starvation and, secondly, to enable the operator to observe the flow of fuel for starting purposes.

Switches, potentiometer and meter socket should be grouped in close proximity for convenience when tuning. This view of an uncovered fuselage shows a suitable arrangement with a typical 0-5 m/a meter in position.

Close-up of a "Sparky" tail assembly with rudder crank in the "right" position. Note tinplate rear bearing which fits round stern post. Fuselage sheeting then goes over this securing it in position.

The E.C.C. 951B Receiver which incorporates the P100 polarised relay is shown here resting on its plastic case. A suitable 6 pin socket is supplied, through which all leads, including the aerial, can be run.

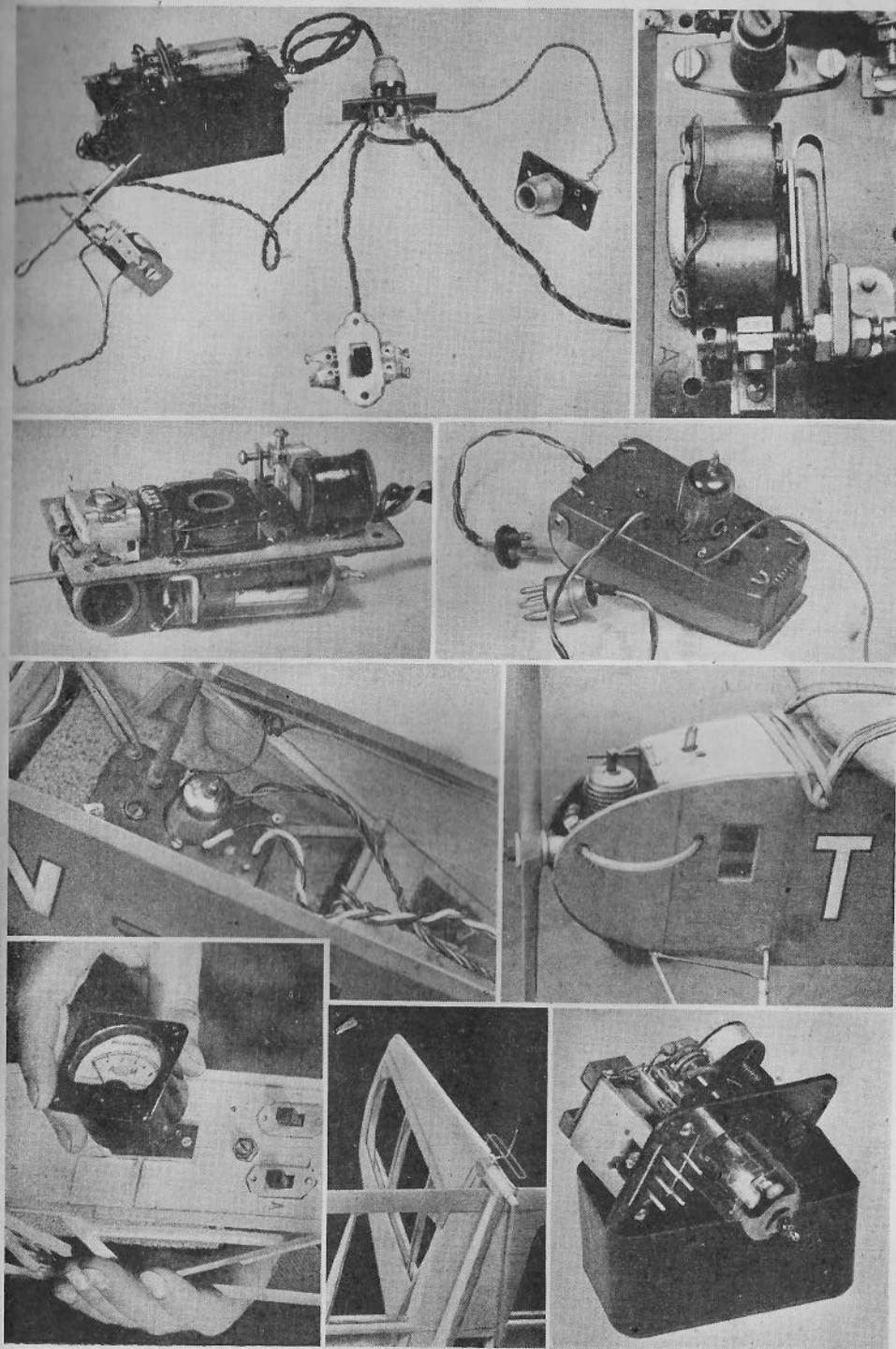
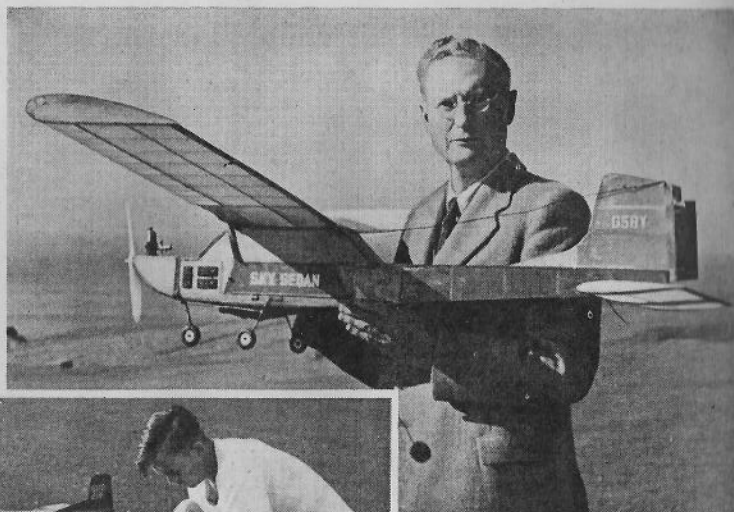


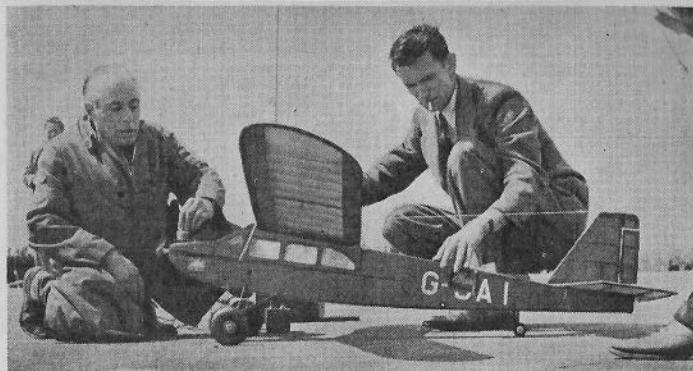
PLATE VII

Right, Hilton O'Heffernan made a radio controlled flight of 2 hrs. 31 mins. 20 secs., with this model, using an "Aeromodeller" Receiver incorporating an E.C.C. 5A relay. Power unit was a Mills 1.3 c.c. diesel, and the model was landed within 94 yards of the transmitter to establish a World Record in October, 1954.



Left, Don Adams won the Australian R/C Championships with the "Live Wire Senior" model he is adjusting in this photo. The design is famous as an American kit, and is available in three sizes, another of which appears in the background.

Sid Allen, for several years the British R/C Champion, is here running up the E.D. 3.46 c.c. motor on one of his models, assisted by Ted Hemsley. These two enthusiasts, together with George Honnest-Redlich, have been responsible for a tremendous amount of development work in the radio control field, particularly with tuned reeds. In 1954 George and Sid made model history by crossing the English Channel with an E.D. "Radio Queen."



As will be gathered from a study of the various plates in this book, radio control flying is truly an international sport. Here is Mynheer Veenhoven of Holland with a clean looking cabin design powered with one of his own "Typhoon" 2.5 c.c. diesels, which he manufactures in Amsterdam. Model uses a single channel hard valve receiver built by the designer, and is controlled by rudder only.

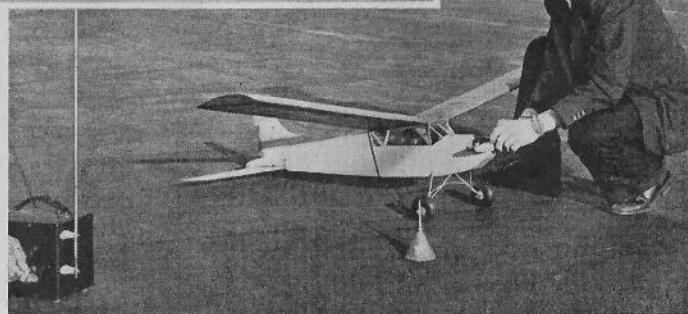


PLATE VIII

LIST OF THE MAIN BATTERY TYPES USED IN RADIO CONTROLLED MODEL AIRCRAFT.

By courtesy of the EVER READY COMPANY (Great Britain) LIMITED.

Apparatus	Battery Type	Voltage	Dimensions (inches) L. W. H.	Weight lbs. ozs.	Contacts	Retail Price
Ground Transmitter (large)	HT—Winner 120 ... LT—A.D.1 ... or A.D.32 ...	120 1.5 1.5	8 1/2 x 2 1/2 x 5 1/2 6 1/2 x 2 1/2 x 2 1/2	6 3 1 11 1 10	2-Pin 2-Pin	13/9 4/- 4/-
Ground Transmitter ...	B.136 Combination battery or B.103	90 and 1.5 90 and 1.5	7 1/2 x 4 x 3 1/2 8 1/2 x 3 1/2 x 5 1/2	5 8 7 2	4-Pin 4-Pin	16/- 18/-
Hand Transmitter ...	HT—B.101 (used in pairs) LT—D.18 ... or D.19 ...	67.5 1.5 1.5	2 1/2 x 1 3/8 x 3 3/4 1 1/2 dia. x 3 1/2 1 1/2 dia. x 3 3/4	12 2 1/2 3 1/2	2 Press Studs 2-Pin 2-Pin	12/- 8d. 1/-
Hand Transmitter ...	B.114 (Combined battery)	69 1.5	4 1/2 x 1 3/8 x 3 1/2	1	4-Pin	7/9
Aircraft Receivers ...	HT—B.122 (Mainly used) LT—D.14 or U.12	22.5 1.5	1 1/2 x 1 3/8 x 2 1 1/2 dia. x 2	1 1/2 1 1/2	End Caps Cap and Zinc	2/6 3d.
Aircraft Receivers ...	HT—B.110 ... LT—D.14 or U.12	22.5	1 1/2 x 1 x 2 3/4 See Above	2 1/2	End Caps	3/-
Aircraft Receivers ...	HT—B.123 ... LT—D.14 or U.12	30	1 1/2 x 1 3/8 x 2 3/4 See Above	1 1/2	End Caps	3/3
The low tension Rudder Actuator ...	battery is decided by size of air craft but in series ... 3—U.12 in series ...	craft but in 4.5	the main, D.14, U.12, 2 1/2 x 7/8 x 2 3/4 See Above	D.18 or D.19 3 1/2	9 are used. Brass Strip Terminals	11d.

BRITISH COMMERCIAL RADIO CONTROL EQUIPMENT

Manufacturer and name of Equipment	Transmitter	Receiver	Actuators Servo Gear Etc.
E.C.C. (Telecommander) Ltd. Telecommander House, Bury Wharf, Ruislip, Middx.	1061 Hand Held Transmitter. Two 3A5 (DCC 90) valves in interrupted Carrier Wave Circuit. $\frac{1}{2}$ wave monopole aerial. Push button controls. Plastic case with unit mounted in reverse of alloy front panel. Batteries: H/T 2 \times 67 $\frac{1}{2}$ v. L/T 1 $\frac{1}{2}$ v. Size: 10 \times 6 $\frac{1}{2}$ \times 2. Weight 3 lbs.	951A Receiver. Quench type super-regenerative receiver with primary and secondary tuning controls. Enclosed in black plastic case complete with plugs, sockets and wire. 3Q4 (N18) hard valve. Contains type 5A balanced armature relay of 3000 ohms. Size: 2 $\frac{1}{2}$ \times 1 $\frac{1}{2}$ \times 1 $\frac{1}{2}$. Weight: 2 $\frac{1}{2}$ ozs. H/T 60-90 v. L/T 1 $\frac{1}{2}$ v.	Type 404 Actuator. Rubber Driven 3-4 $\frac{1}{2}$ volts.
ECC.951A.	Transmitter as above.	Receiver as above but with P100 Polarised Relay of 3500 ohms. Complete with special 6 pin socket. Weight: 2 $\frac{1}{2}$ ozs.	
ECC.951B.	Transmitter as above.	Receiver as above but with P100 Polarised Relay of 3500 ohms. Complete with special 6 pin socket. Weight: 2 $\frac{1}{2}$ ozs.	
ECC.1051.	1051 Transmitter Unit for assembly in own case. Specification as per 1061.		
Electronic Developments Limited, 18 Villiers Road, Kingston-upon-Thames, Surrey.	Boomerang Transmitter. Single 3A5 (DCC 90) valve in cross fed Hartley circuit. 4 watts input. $\frac{1}{2}$ wave vertical monopole aerial in 4 sections. Metal, crackle finished case complete with keying lead and micro switch. Size: 9 $\frac{1}{2}$ \times 7 $\frac{1}{2}$ \times 8 $\frac{1}{2}$. H/T 120 v. L/T 1 $\frac{1}{2}$ v. Weight: 11 lbs.	Soft Valve Version. Hivac XFG1 gas triode in super-regenerative circuit with five aerial matching connections. Contained in plastic case. Size: 3 \times 2 \times 1 $\frac{1}{2}$. H/T 45 v. L/T 1 $\frac{1}{2}$ v. Weight: 3 $\frac{1}{2}$ ozs. Hard Valve Version. 354 (DL92) valve in super-regenerative quench coil circuit. H/T 60-90 v. L/T 1 $\frac{1}{2}$ v. N.B. Both Boomerang receivers are wired ready for use complete with switches, plugs and actuator.	Mk. III Actuator. Elastic Driven, double coil, current saving, self neutralising type. 4 $\frac{1}{2}$ v. Size: 1 $\frac{1}{2}$ \times 1 $\frac{1}{2}$ \times 2 $\frac{1}{2}$. Weight: 1 oz.
Boomerang			
Mk. II	3A5 (DCC90) valve in dual purpose carrier, keyed, and modulation keyed circuit, 3 $\frac{1}{2}$ watts input. Size and voltages as per Boomerang.	Three deaf-aid miniature Mullard DL66 valves in a positive feed back circuit giving a current rise on receipt of a modulated signal. This gives extreme ranges of over 2 miles with low battery consumption. Size: 4 \times 2 $\frac{1}{2}$ \times 1 $\frac{1}{2}$. H/T 45 v. L/T 1 $\frac{1}{2}$ G/B 6V. Weight: 4 $\frac{1}{2}$ ozs.	Actuator as per Boomerang.
Mk. IV Senior, Miniature and Everest.	3A5 (DCC90) double triode and DC 92 Pentode in a modulated carrier circuit. Quarter wave vertical monopole aerial. Size: 9 $\frac{1}{2}$ \times 8 $\frac{1}{2}$ \times 7 $\frac{1}{2}$. H/T 120 v. L/T 1 $\frac{1}{2}$ v. Weight: 11 $\frac{1}{2}$ lbs. Control Box. Size: 6 \times 5 \times 2 $\frac{1}{2}$. Weight: 1 $\frac{1}{2}$ lbs. A double acting lever switch and a push button switch for selecting the three channels. Control Box for "Miniature" same as per "Senior". Control Box incorporating two double acting lever switches and two push button switches. Size and weight as per Senior and Miniature.	Senior. Two Mullard DL66 and one DL92 in a circuit feeding a three reed unit, the output of which operates three polarised relays. Size: 5 \times 3 $\frac{1}{2}$ \times 2. Weight: 9 ozs. Miniature. Two DL66 and one DL68 valve in a circuit feeding a three reed unit and in turn three polarised relays. Size: 4 $\frac{1}{2}$ \times 3 \times 2 $\frac{1}{2}$. H/T 45 v. L/T 1 $\frac{1}{2}$ v. Weight: 10 ozs. Everest. Receiver is the same as the Miniature but a six reed unit is used operating six polarised relays.	According to requirements of model Mk. I, Mk. III or motorised actuators can be used. Mk. I Actuator. Clockwork operated, interchangeable two or four pawl, giving greater power than rubber driven types. Size: 3 \times 1 $\frac{1}{2}$ \times 2. Weight: 3 ozs. 4 $\frac{1}{2}$ v. Motorised Actuator. Ever-Ready electric motor actuator incorporating circuit switches enclosed in plastic box. Size: 2 $\frac{1}{2}$ \times 1 $\frac{1}{2}$ \times 1 $\frac{1}{2}$. Weight: 5 ozs. 3-4 $\frac{1}{2}$ v.

Manufacturer and name of Equipment	Transmitter	Receiver	Actuators Servo Gear Etc.
Lines Bros. (Richmond) Ltd. 16-18 Petersham Road, Richmond, Surrey.	Triang Radio Master Mk. I Transmitter. This transmitter uses a single 3D6 valve, is tunable, and incorporates a pre-set absorption wavemeter for frequency checking. It can emit either an unmodulated carrier wave, or a pulsed carrier wave in which both mark/space ratio and the pulse rate can be varied within certain limits. $\frac{1}{2}$ wave and $\frac{1}{4}$ wave monopole aerial are available, the latter for boats. Size: 8 \times 4 $\frac{1}{2}$ \times 5 $\frac{1}{2}$. H/T 90 v. L/T 1 $\frac{1}{2}$ v. Weight: 9 lbs.	Triang Aircraft Receiver. Super-regenerative quench type receiver employing a sub-miniature hard valve — the DL68. The unit has Plessey printed silver wiring, a standing current of 2.4 m/a and a current change of 1.5 m/a. It incorporates a double pole, double armature, polarised relay of 7,000 ohms and is totally enclosed in a hermetically sealed plastic case. Size: 3 $\frac{1}{2}$ \times 2 \times 1 $\frac{1}{2}$. H/T 60 v. L/T 1 $\frac{1}{2}$ v. Weight: 4 $\frac{1}{2}$ ozs.	Triang Radio Slave. A self-contained motorised actuator and power unit for the propulsion and control of model boats. It uses a Frog "Tornado" servo motor and a Cursor unit for the actual steering. It is not suitable for model aircraft. Size: 8 \times 3 \times 1 $\frac{1}{2}$. H/T 60 v. L/T 1 $\frac{1}{2}$ v. Motor 3 v. Weight: 1 lb. 4 ozs.
A. T. Sallis, 93 North Road, Brighton, Sussex.	Transmitter. A push-pull Colpitts oscillator, carrier operated, using two 3D6 valves. Case with chromium handle is available as separate item. Case will be drilled to purchaser's own requirements to take meters, ecc. for post and packing charge only. Size: 7 $\frac{1}{2}$ \times 8 $\frac{1}{2}$ \times 10 $\frac{1}{2}$.	Receiver. Super-regenerative quench type receiver using a 354 (DL92) single hard valve. Incorporates a balanced armature 5,000 ohms relay. Size: 3 \times 2 \times 2. H/T 60-90 v. L/T 1 $\frac{1}{2}$ v. Weight: 4 ozs.	

APPENDIX III

G. A. DRAWINGS OF WELL KNOWN RADIO MODELS (pages 84-87 inclusive)

LIVEWIRE By Harold de Bolt

Probably the most famous of American kit designs, which is available as a family of three in varying sizes.

LIVEWIRE SENIOR 5 ft. 4 ins. span, wing area 750 sq. ins., weight 60 ozs. min., 90 ozs. max., suitable for 3 $\frac{1}{2}$ to 5 cc. motors.

LIVEWIRE TRAINER 4 ft. span, wing area 432 sq. ins., weight 35 ozs. min., 48 ozs. max., suitable for 1.3 to 1.5 cc. motors.

LIVEWIRE KITTEN 34 in. span, wing area 220 sq. ins., weight 18 ozs., suitable for .8 cc. to 1 cc. motors.

Design uses a symmetrical tailplane at 0 degrees incidence, mainplane at +5 degrees. Low C.L.A. gives excellent stability in turns.

RUDDERBUG By Walter Good

A long standing and very famous design by America's leading radio expert. Span is 7 ft., wing area 870 sq. ins., weight 5-7 lb., and power required, between 3 $\frac{1}{2}$ to 5 cc. A remarkably stable model in flight, it has good glide penetration and ample fuselage space for radio equipment. Large doors tend to create a weak spot beneath the wing seating, and it is recommended that the balsa structure should be replaced by hardwood at this juncture. The tricycle undercarriage gives very stable take-off characteristics, and torsion bar suspension is recommended for the nosewheel. Rigging is:—mainplane at 0 degrees, symmetrical tail at -2 $\frac{1}{2}$ degrees, thrustline 0 degrees.

RUDOLPH By Dick Schumacher

A 5 ft. span contest radio job by another American expert. Simple slab-sided construction and a tensioned rubber sprung landing gear, make a practical and purposeful model. Power is provided by a "K & B 19" 3 $\frac{1}{2}$ cc. motor on the original, this engine being fitted with two-speed control operated by the Bonner system. Wing area is 600 sq. ins., weight 30 ozs. approx. Rigging:—mainplane +5 degrees, symmetrical tail at 0 degrees, and 3 degrees downthrust on the motor.

WINDY JOE By Bill Winter

Designed for the early E.D. 2 cc. Comp Special this simple design by the Editor of "Model Airplane News" is suitable for beginners: powered with a modern 1.5 cc. diesel, or the expert with a $3\frac{1}{2}$ cc. up front. Span 52 ins., wing area 416 sq. ins., section Thin Clark Y, rigging:—mainplane 0 degrees, symmetrical tail at -2 degrees, engine downthrust 5 degrees. C.G. is between 25 and 30 per cent.

THE JAVELIN By Hank Bourgeois

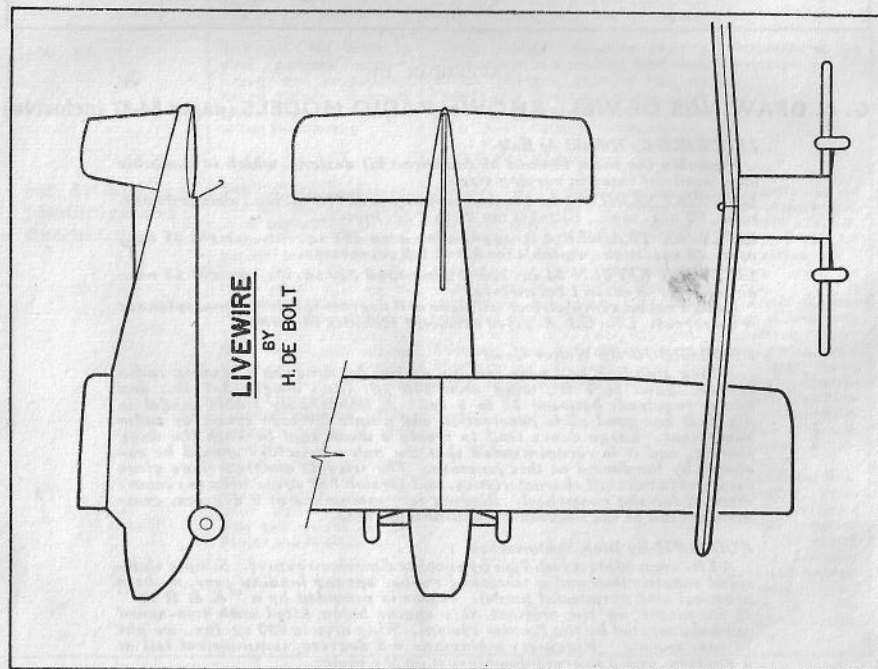
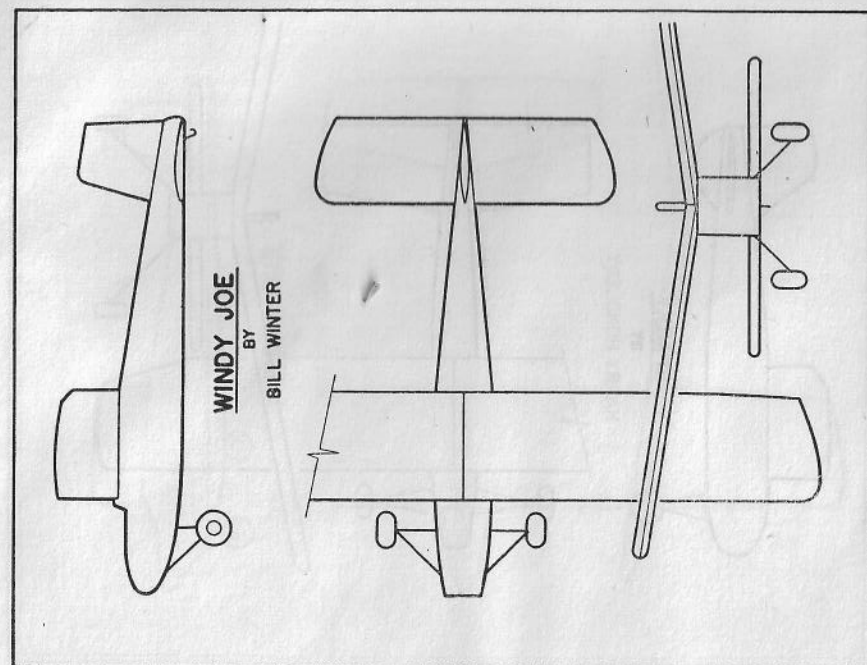
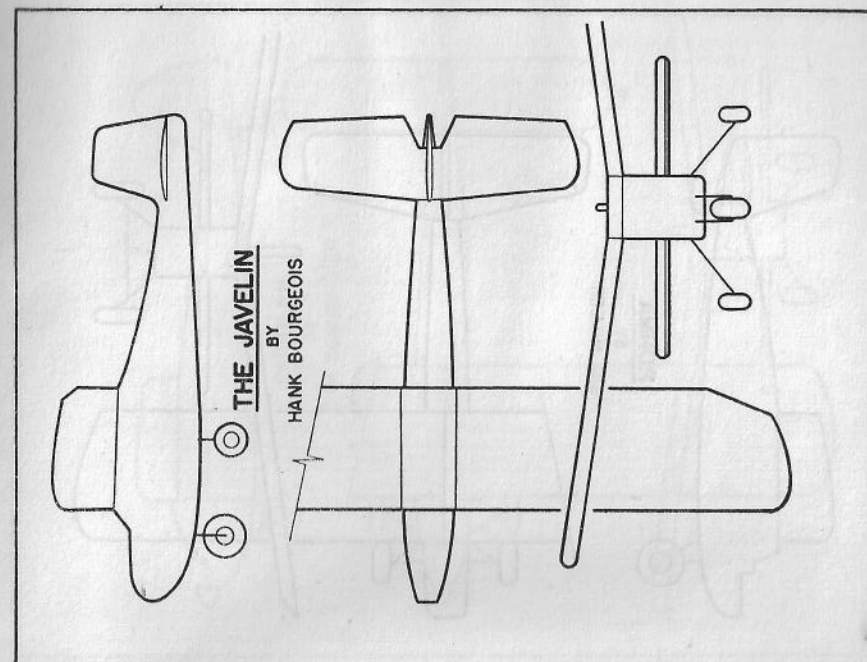
A conventional 54 in. span cabin type model for $1\frac{1}{2}$ to 2½ cc. motors. Original used a "Ruddervator" for control in place of the orthodox rudder. This is an angled rotating vane fitted aft of the fuselage and attached to the actuator shaft. It can be stopped in four different positions giving "Left and Up", "Left and Down", "Right and Up", "Right and Down". For neutral the vane merely freewheels. Rigging on "Javelin" is mainplane 0 degrees, tailplane -4 degrees, motor 2 degrees downthrust.

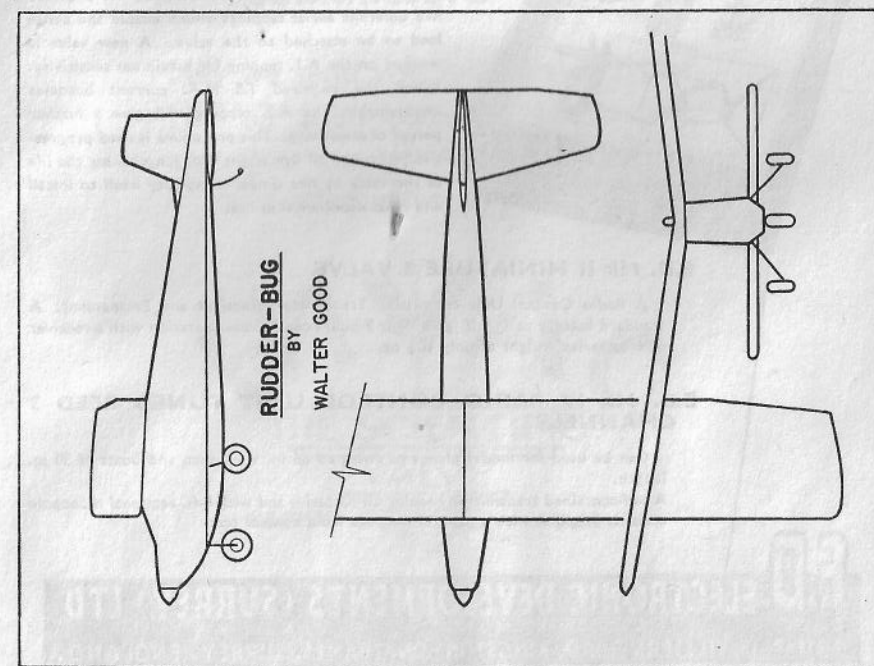
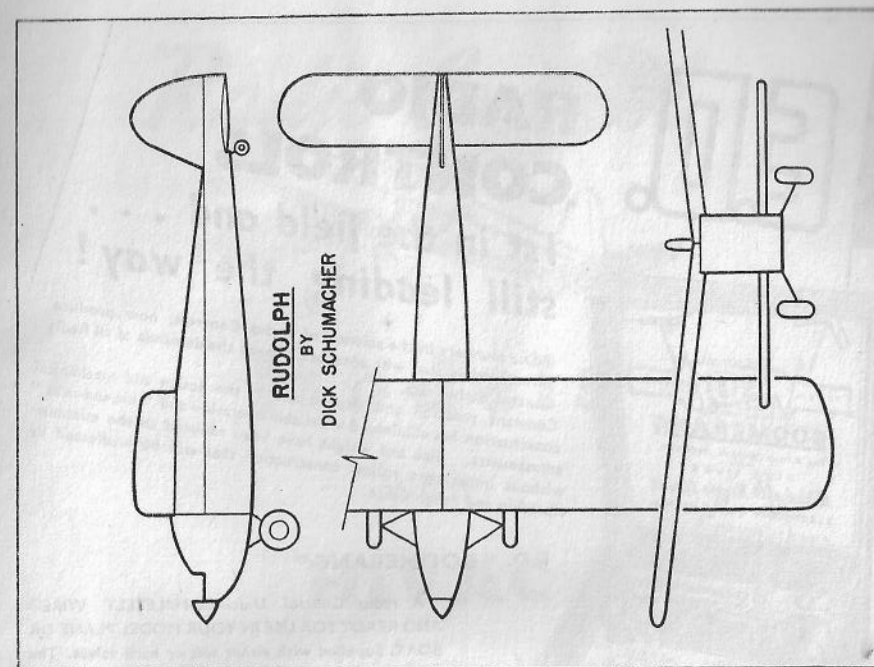
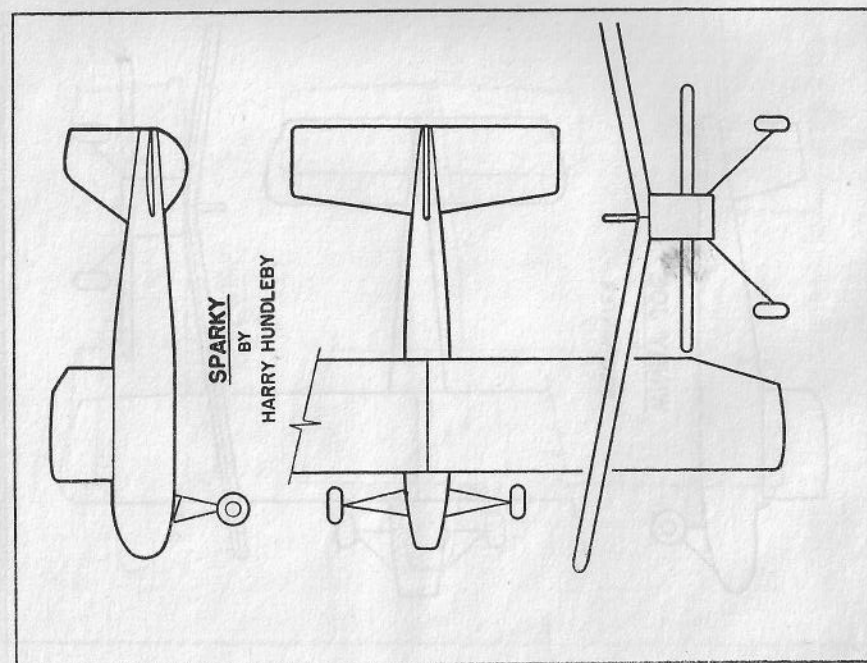
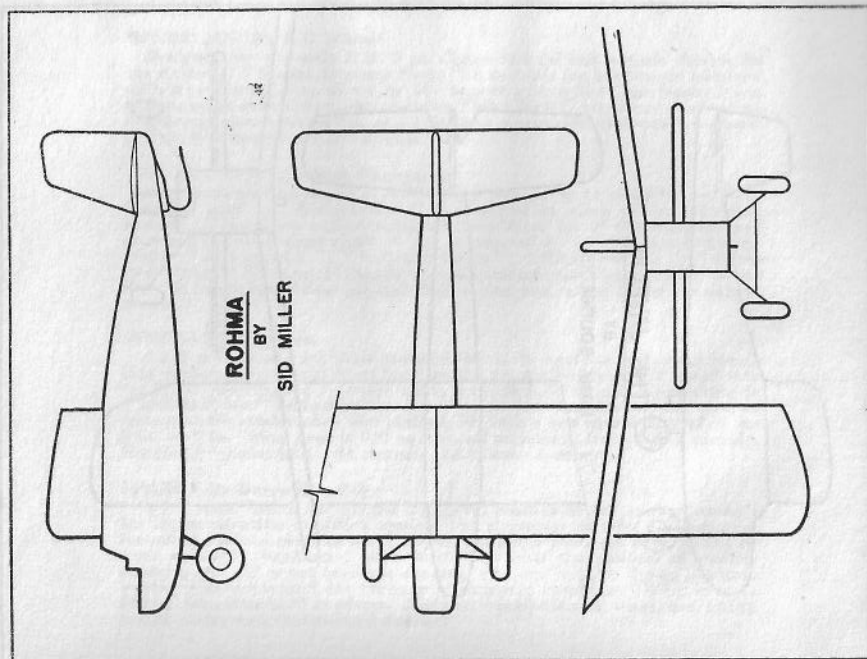
ROHMA By Sid Miller

A 5 ft. 4 in. span high wing radio trainer with exceptionally easy handling abilities that make it an ideal model for the beginner. It is suitable for 3½ cc. motors, the original using an E.D. 3.46 diesel. Everything is "knockoffable" including the complete motor nacelle, and for ease of transport the model when dismantled, fits into a box measuring 42 in. by 9 in. by 9 in. Wing area is 630 sq. ins. all up weight from 3 to 4 pounds. Rigging:—mainplane +1½ degrees, tailplane -1 degree.

SPARKY By Harry Handleby

A 4 ft. span functional design for 1.5 cc. motors by the author, notable for its penetrating qualities against the strongest of winds. Designed for aerobatic competition work, hence the short moment arm, it can be used safely by beginners, providing they limit the amount of rudder movement. All sheet fuselage construction and simple flying surfaces enable it to withstand the rigours of inexpert handling. Wing area is 360 sq. ins., weight 30 to 40 ozs. Rigging:—mainplane at 0 degrees, lifting tail at -2 degrees, thrustline 0 degrees

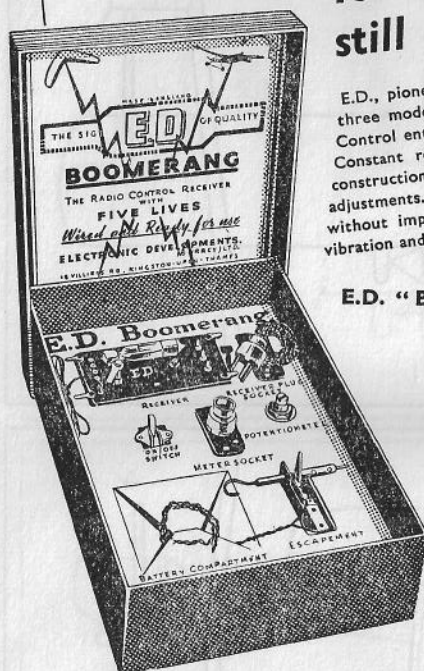




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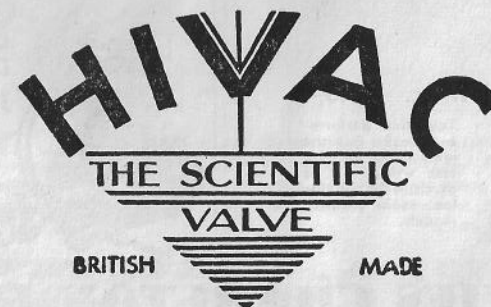
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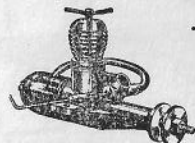
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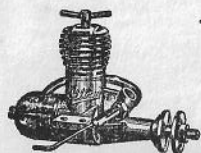
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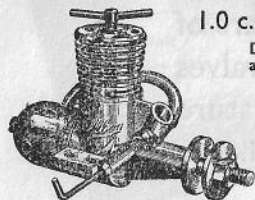
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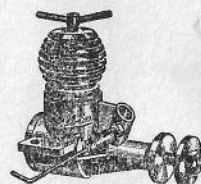
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1.0 c.c. 64/2

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JAVELIN



1.49 c.c. 65/4

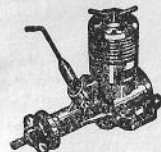
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.76 c.c. 47/6

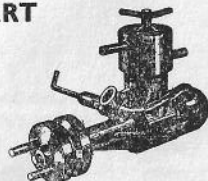
The perfect all-rounder. Terrific performance at low cost made possible by quantity production. Beam or Radial mounting.



MARINE DART

.5 c.c. 83/10

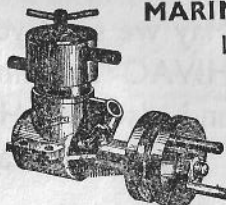
Ideal for small boats. Complete with special water cooled jacket and flywheel.



MARINE JAVELIN

1.49 c.c. 85/2

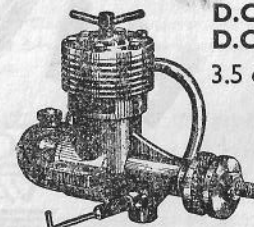
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D.C. 350 &
D.C. 350 (G)

3.5 c.c. 78/5

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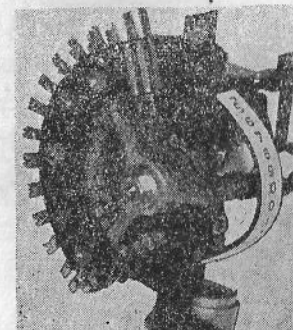
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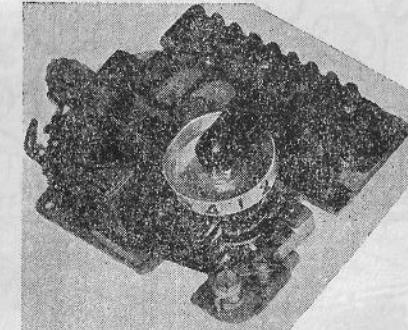
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SPARKY. By H. G. Hundleby. R/C 447. Price 4/-
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