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NOVEMBER 1960

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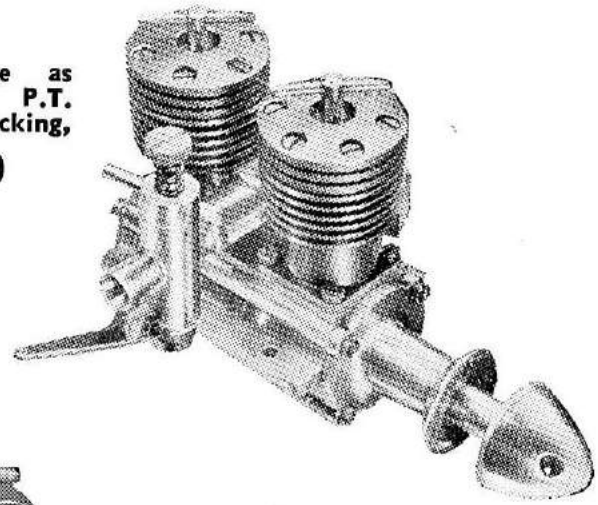

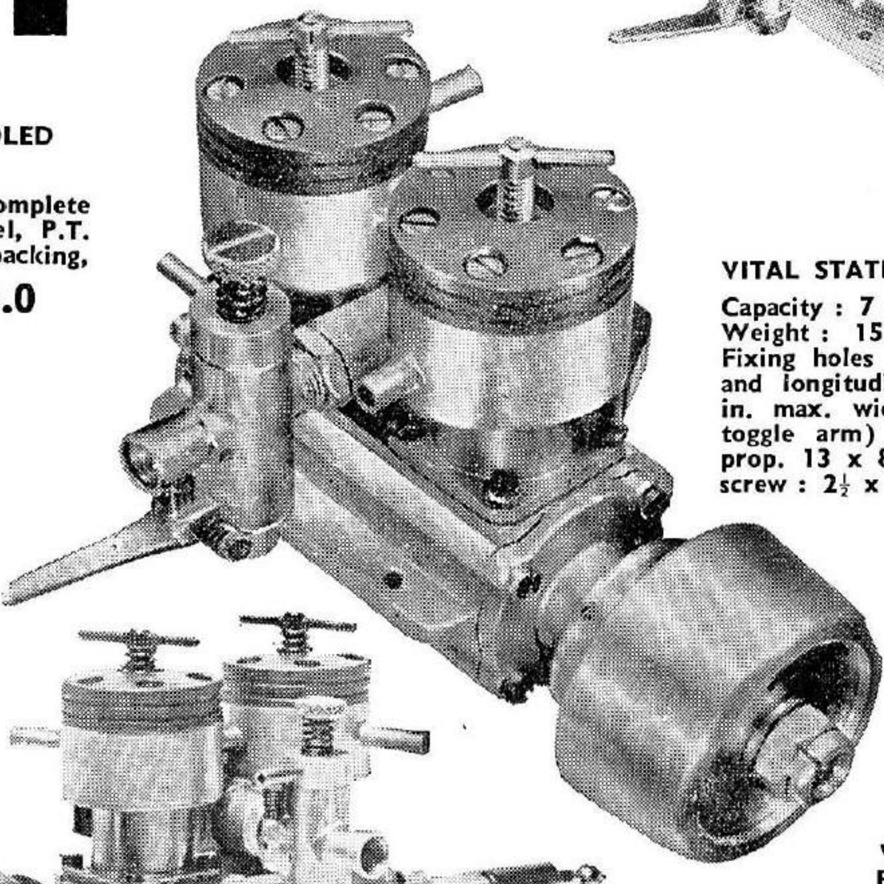

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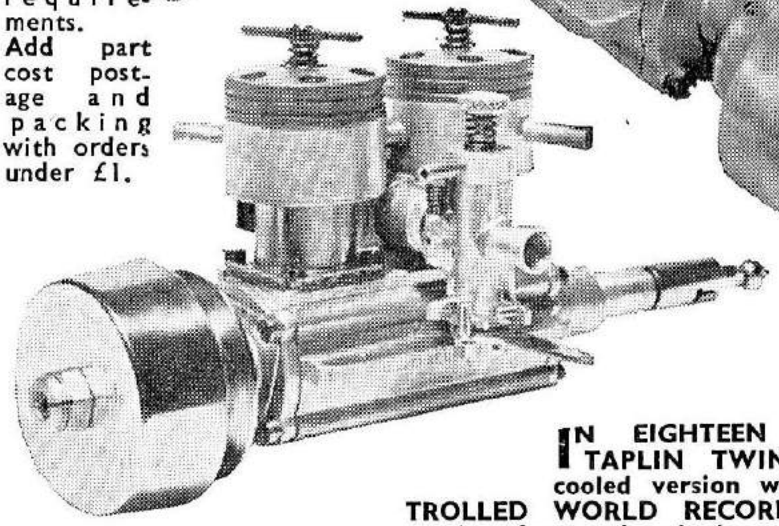

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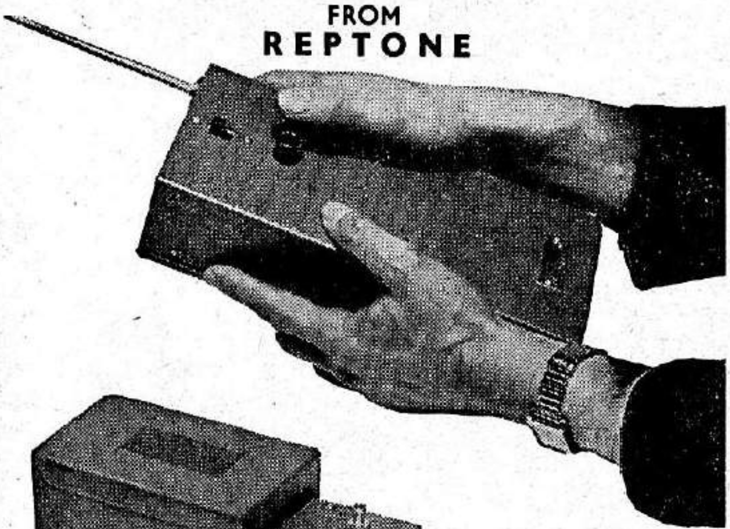

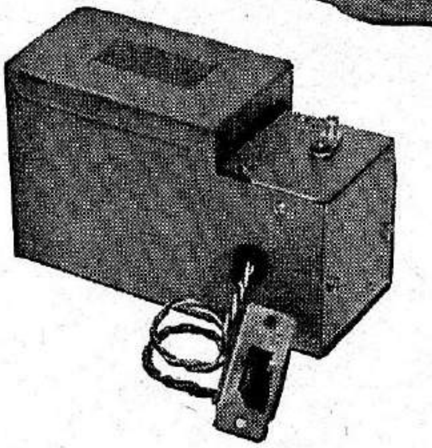

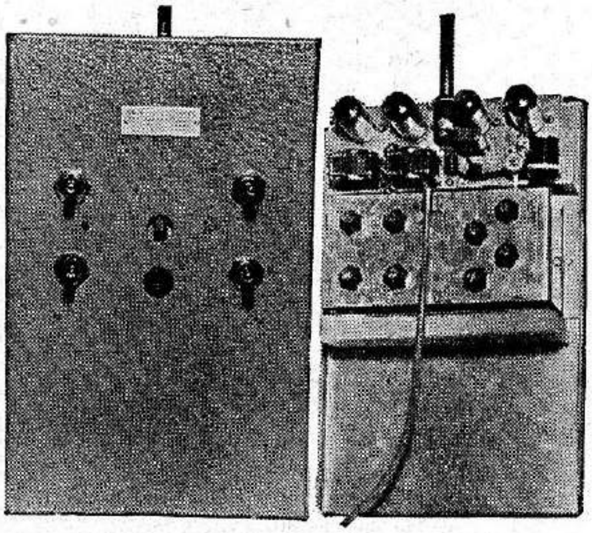

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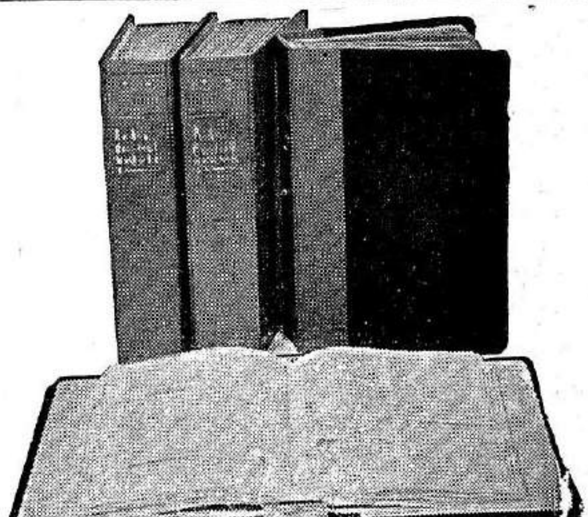

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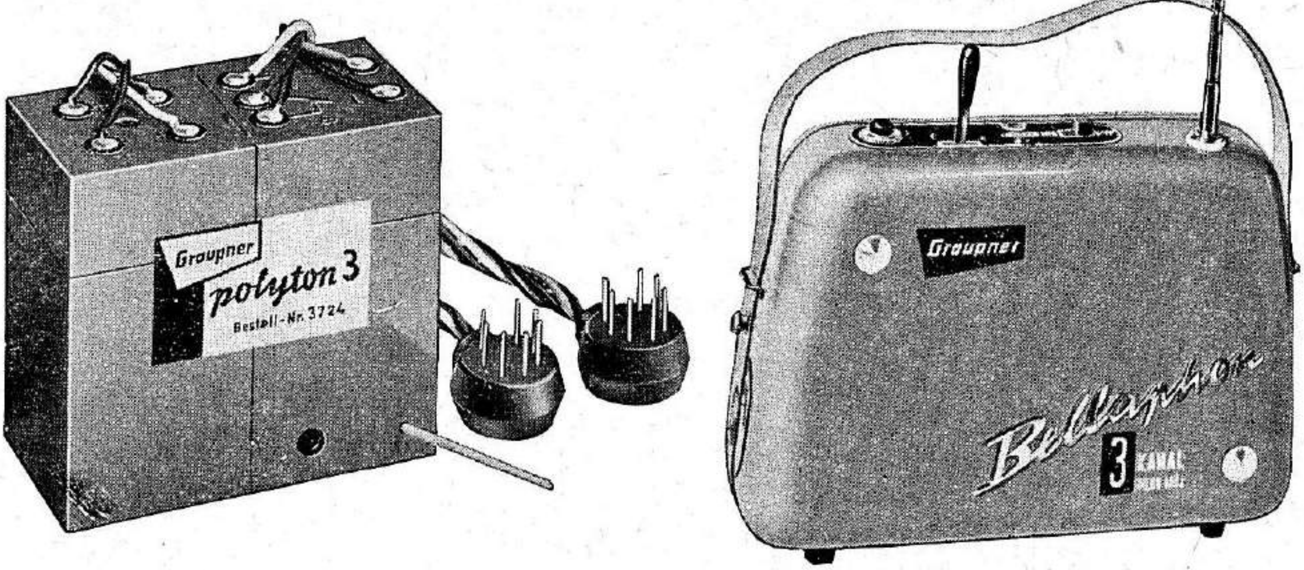

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Ed. Johnson, Radio Control

LARKHILL WILTS ENGLAND

Radio Control Models & Electronics

VOLUME 1 NUMBER 7 NOVEMBER 1960

Editorial Director : D. J. Laidlaw - Dickson.
CONSULTING EDITOR : T. H. IVES.
Advertisement Director : C. S. Rushbrooke.
Editorial and Advertisement Offices :
38 CLARENDON ROAD : WATFORD : HERTS
Telephone : WATFORD 32351/2 (Monday to Friday).

Here, There & Everywhere

Radio Flying Scale ?

ONCE upon a time when i.c. motors were not very small, cheap or reliable and rubber was sold by the mile, the sight of a scale model aircraft was comparatively rare, its fidelity to scale given a kindly latitude, and any sign of its being airborne greeted with delight. Today, in both the free flight power and control line sections of our hobby a contest for scale models brings a choice entry of really beautiful machines and provokes immense interest amongst both expert and lay spectators. Are we ready for the promotion of scale contests for radio controlled models?

One club at least thinks we are, and is prepared to back its belief with the offer of half a dozen knowledgeable members able and willing to run such an event. We cannot do better than quote the letter from Sutton Coldfield R.C.M.A.C. in full:—

From SUTTON COLDFIELD R.C.M.A.C.

Dear Sir,

As a result of a discussion at a recent Club Meeting, I have been authorised by members to write to you in connection with the possibility of including in the 1961 Contest Calendar an event for Radio Controlled Scale Model Aircraft.

It is felt that the time has arrived when scale modelling has a considerable following, increasing daily in popularity, more especially with the ever-mounting interest in radio control and the considerable advance towards radio equipment which has been made.

The construction of scale model aircraft and flying under radio control appears to us the ideal combination, and the ultimate goal to be able, combined with the skill of the pilot, to carry out the full schedule of aerobatics.

This trend is evident in the semi-scale appearance of aircraft flown by the leading countries, including Britain, in the recent World Championships.

Without wishing to burden you with lengthy correspondence, it can be pointed out that the British Nationals cater for free flight scale and control line scale, both proving to be popular. Therefore why not a Radio Control Scale Event? It is appreciated that already programmes are heavily loaded, but sooner or later room must be found for this event.

To conclude I would add that six club members have volunteered to assist in any

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Subscription Rates : 12 months (home), 28/6; (overseas) 27/6, including enlarged Christmas Number.

way the organizing and running of this event, should it be sanctioned.

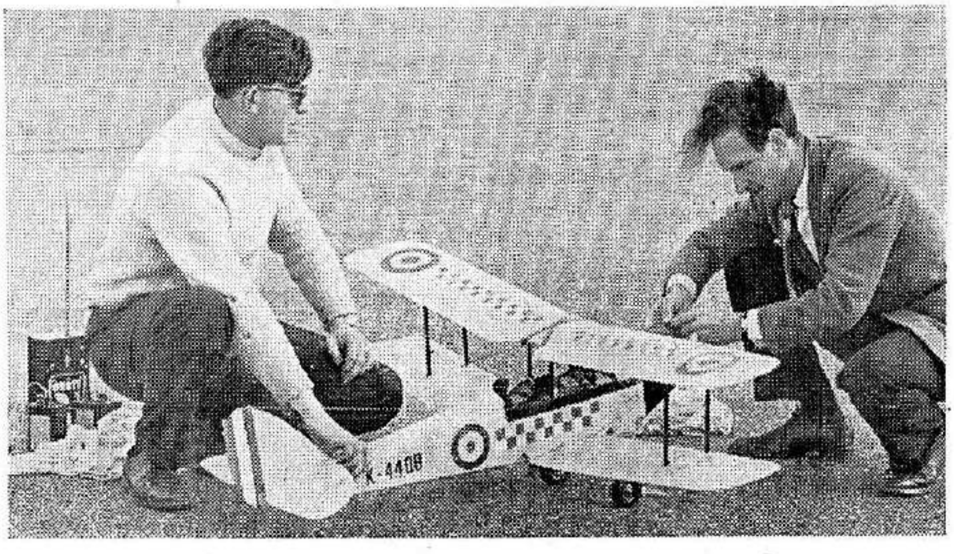
Yours faithfully,
G. A. V. MARSH,
President.

Scale models at the present time must take their chance in open competition against specially designed R/C machines. Denis Thumpston's (Sutton Coldfield, by the way!) *Fokker* was able to take third place at this year's Nationals against all comers in single channel. We do not think his is an isolated example, as a quick shuffle through recent contest pictures produces J. Morton's (A.R.C.C.) *Gipsy Moth*, a multi using OS Max 35 and Orbit 4-channel equipment which is a definitely eye-catching performer, and C. Cooke's *E.P.9* seen at the S. Midland Rally, which did not live up to its looks on that occasion. Then there is the veritable school, squadron, or what have you, that E. P. Norman flies so consistently well on every possible occasion. Add to this the growing crop of Goodyear Racer types in course of development for pylon racing and we have the basis of an entry.

We do not know how the S.M.A.E. would look upon the idea of squeezing yet another event into the Nationals. If it is felt that the programme is already full to overflowing, then a date for it could perhaps be found elsewhere in the calendar. Anyway, here is a good idea, willing workers and lots of future . . . we would welcome readers' comments.

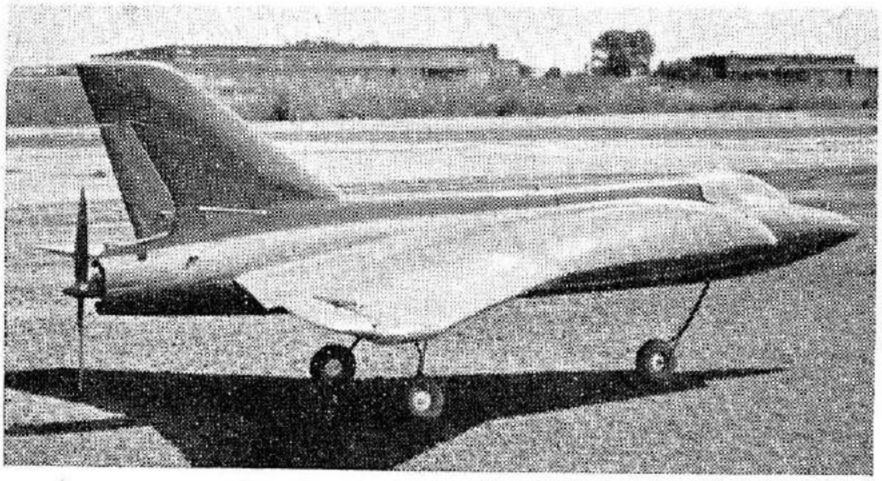
Aftermath of Duberndorf

We have now had an opportunity of reading what our fellow scribes had to say about the recent World Championships in Switzerland. All were agreed on the quality of the flying, and the relative merits of entrants with surprisingly little variation on points of detail, virtually none on matters of moment. All were loud in their praise of organisation in general and nearly all made the qualification, either in muted tones of apology, or in more outspoken terms "except for the judging". The necessary attributes of a judge are surely primarily that he should be competent to judge? Not perhaps an ability to fly as well as the entrants (after all very few boxing referees could at any time have k.o.-ed their charges!) but certainly a wide experience of seeing R/C models at their best, a degree of independence of thought and action, and rational approach to marking. It matters not a whit if Judge A marks low, and Judge B high, so long as their standards are constant. Throwing away top and bottom scoring is ridiculous, since it often means the most expert judgment is discarded. Let us have judges chosen for their judgment not high officials of the F.A.I. who may well be expert in quite different fields. If such officials must be honoured, then surely their place is on a Jury of Honour? The next event is in 1962, let us hope a good crop of "wise and upright judges" have matured by then.



Above: C. Cooke's E.P.9 which competed at both I.R.C.M.S. and South Midland Rallies though alas without success.

H. Morton of A.R.C.C. with his Orbit R/C Gipsy Moth, which has been performing well at recent meetings, and is a harbinger of models that can be expected in the future.



Prototype of Gunter Schmidt's glass fibre model, which shows its sleek lines so well suited to this modern medium to advantage.

Glass Fibre for Model Aircraft

So far modellers have failed to make the fullest use of glass fibre as a construction medium, but our correspondent Bill Park reports from Germany of at least one enthusiast using it in a big way. We illustrate *GSD* 60-7 an o/d delta by Gunter Schmidt of Bremen—which is all glass fibre airframe except rudder and elevons. It has been developed over four years in normal balsa construction, and can now be moulded on a plaster form. The whole model, including radio installation takes two weeks of evenings to complete start to finish! Almost indestructible fuselage and wing requires no internal structure. Span is 40 ins., length 47 in., with about 650 sq. in. wing area. Prototype, shown here, has Webra Bully 3.5 c.c., Teco E.12 all transistor Rx., EKV actuator, and all-up weight of 5½ lbs. Elevons are spring loaded, screw adjustable with 8° deflection up. Production models, no u/c, will have 3-channel Rx. (2 rudder 1 motor), OS Max 29-35, and are expected to weigh about 4¾ lbs.

Cover Picture

Our picture has already been captioned by the unkindly, "Hear no evil, speak no evil, see no evil" and shows Taplin Père with sons Michael and John and none other than Henry J. Nicholls, taken at the popular Poole Radio Regatta. This is, of course, the normal habitat of the Taplin family, but to find Henry J. in the vicinity of water once again is a welcome surprise. Older R/C fans will remember Henry's pioneer work in producing the first British commercial equipment, the ill-fated Mercury-Cossor receiver and transmitter. At that time his interests included both aircraft and boat operation, and we can well remember going with him to try out his Vosper A.S.R.L. on a local pond at Dover as early as 1949, when the M-C sequential control produced the whole gamut of eight operations quite faultlessly in his hands.

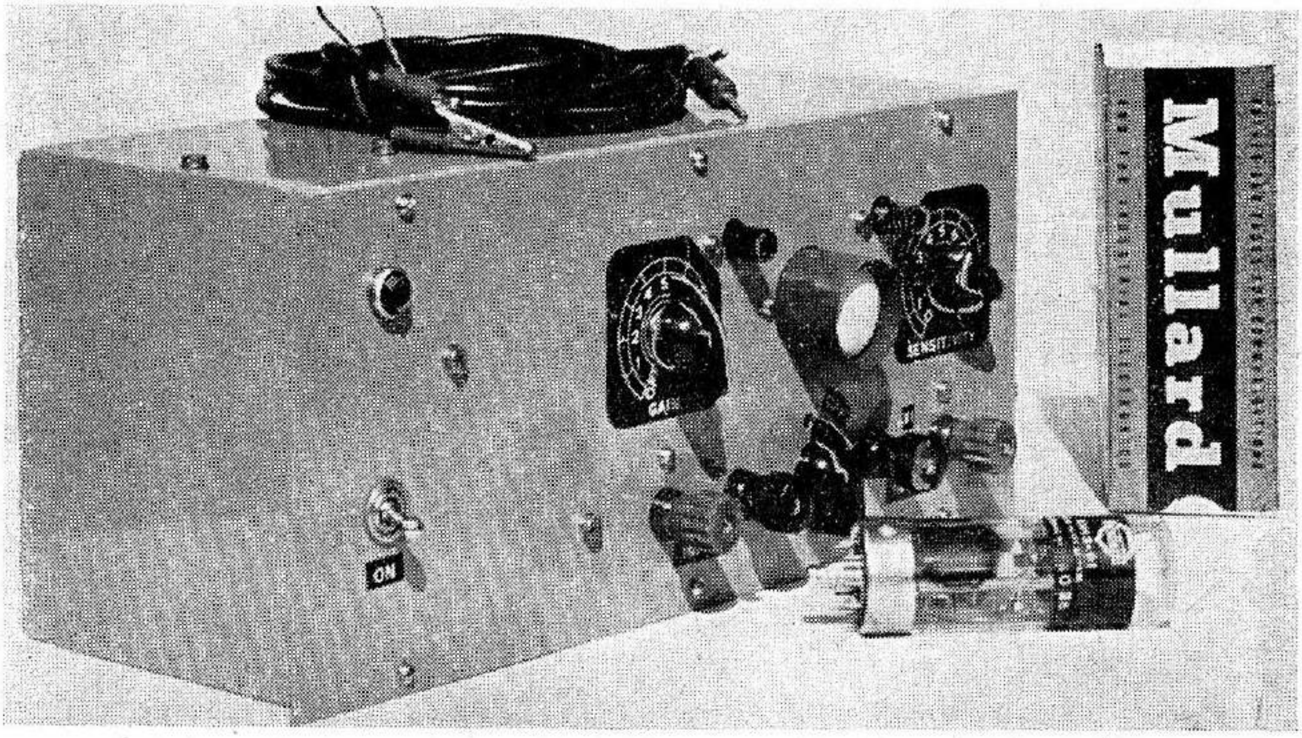
Now once again, our Henry is recapturing a desire to "mess about with boats" and is assembling an appropriate fleet for his enjoyment. This in its turn should lead to some new equipment from 308 Holloway Road . . .

Our First Christmas Number

Our December issue will be the first Christmas number we have produced so that very properly it should have a "first time" in it. We have therefore had our experts in something of a huddle to work out a winner and their efforts have produced an all-transistor tone transmitter, using three OC 170s. Naturally, it will be of the hand-held variety, with a high efficiency tuned aerial. Experiments to date make us very optimistic about its performance, though like all new ventures we have no doubt that other experts will reshuffle it in a series of developments to the ultimate benefit of everybody. We would hasten to disclaim originality for our offering, and would pay due tribute to the valuable help we have received from the work and writings of such experts as Hans Diete Heck and Ernst Klauser.

Another Christmas special follows the lines of our Issue No. 1 Slide Rule, which has been immensely popular, on this occasion being a cut-out Resistance Calculator, which requires positively no mathematics to enjoy.

Boat enthusiasts will be catered for in a big way with quite the finest article we have seen on the subject of radio control circuitry for warship pyrotechnics—all of which have been carried out practically—we have the pictures to prove it!



The Complete Simple Oscilloscope, housed in a case 12 in. x 5 in. x 4½ in.—the Mullard 1 in. cathode ray tube type DH-3-91, around which this instrument is designed, can be seen in the foreground.

THE C.R.T. OSCILLOSCOPE

PART 4

Making a Simple Oscilloscope

By F. C. JUDD, A. Inst. E.

THE Oscilloscope described in this article is a simple one and therefore limited in its application. It has been designed, however, to include a two-speed timebase, derived from the 50 cycles mains supply, via the mains transformer. This time base will enable repetitive waveforms at frequencies between about 150 and 10,000 c.p.s. to be examined. Syncronization is not possible with a simple 50 c.p.s. time base, but it will be found quite easy to 'hold' a display long enough for close examination or for photography, particularly at the lower frequencies. When the internal 50 c.p.s. time base is switched off, the valve used for its formation, becomes an amplifier with the 'X' input connected to the grid. An external 'linear' time base can therefore be connected to the 'X' terminals. Otherwise any repetitive waveform may be connected to the 'X' input and its amplitude controlled by the 'sensitivity' control. Simultaneously, any waveform may be connected to the 'Y' input terminals for display in conjunction with either the time base or with any signal applied to the 'X' input. Provision is therefore made for 'Lissajous' pattern work (frequency comparison as outlined in the previous articles).

A 'Y' shift control (VR4) has been incorporated to provide just sufficient movement of the spot to keep the display centered. A Brilliance control has been included also, but this is inoperative when the time base is in use (VR3). In this case the brilliance level is fixed by the application of a 50 c.p.s. voltage to the c.r.t. cathode, which serves primarily to prevent the flyback trace appearing. The additional socket marked 'r.f.' is A.C. coupled, this means that it is coupled via an isolating capacitor, to one 'Y' plate and is for direct injection of an r.f. carrier when it is required to examine any modulation applied to the carrier. This facility may be used with or without the time base.

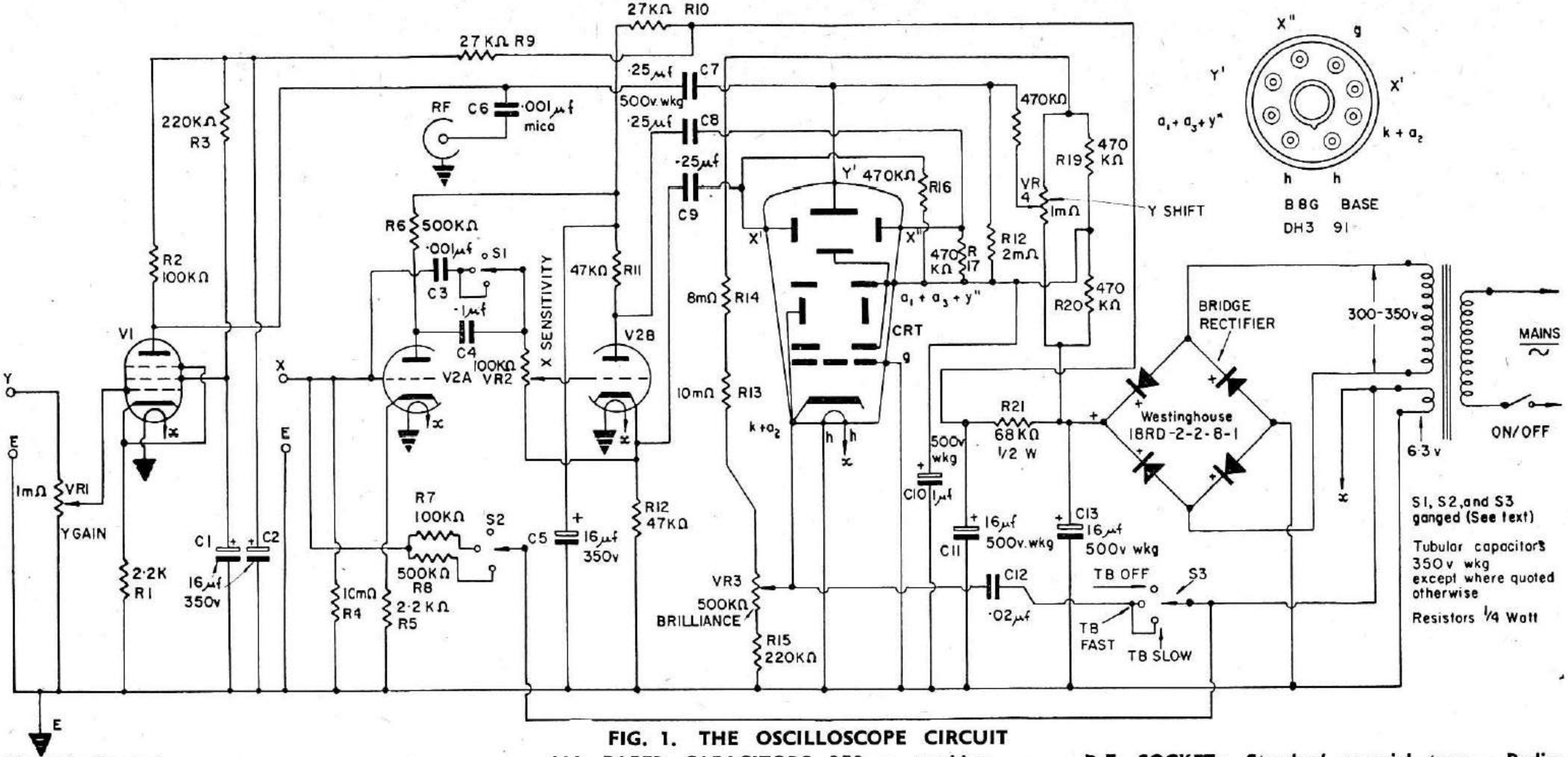


FIG. 1. THE OSCILLOSCOPE CIRCUIT

Variable Controls :

VR1	1 M. ohm Lin.	Radiospares
VR2	100 K. ohm Lin.	do.
VR3	500 K. ohm Lin.	do.
VR4	1 M. ohm Lin.	do.

ALL RESISTORS—¼ watt 10%—RADIOSPARES

R1	2.2 K. ohm	R13	10 M. ohm
R2	100 K. ohm	R14	8 M. ohm
R3	220 K. ohm	R15	220 K. ohm
R4	10 M ohm	R16	470 K. ohm
R5	2.2 K. ohm	R17	470 K. ohm
R6	500 K. ohm	R18	2 M. ohm
R7	100 K. ohm	R19	470 K. ohm
R8	500 K. ohm	R20	470 K. ohm
R9	27 K. ohm	R21	68 K. ohm —½ watt
R10	27 K. ohm		
R11	47 K. ohm	R22	470 K. ohm
R12	47 K. ohm		

ALL PAPER CAPACITORS 350 v. working — RADIOSPARES

C3	.001 μfd.	C8	.25 μfd.
C4	.1 μfd.	C9	.25 μfd.
C7	.25 μfd.	C12	.02 μfd.

ALL ELECTROLYTICS 350 v. working — RADIOSPARES

C1	16 μfd.	C10	16 μfd.
C2	16 μfd.	C13	16 μfd.
C5	16 μfd.		

(NOTE) C1 and C2 and C1 and C3 may be 16 + 16 μfd. capacitors combined.

MICA CAPACITOR : C6 .001 μfd. Mica type—Radiospares.

R.F. SOCKET : Standard co-axial type — Radiospares or Belling & Lee.

BRIDGE RECTIFIER : Westinghouse type 18 RD —2—2—8—1.

VALVEHOLDERS : B9A Noval (2 off), Radiospares ; B8G Loctal (1 off), Radiospares.

SWITCHES : S1, S2, and S3, 3-pole 3-way wafer type — Radiospares ; Mains on/off — Toggle type SPST — Radiospares.

Insulated Input Sockets
Tag Boards
Control Knobs
Pilot Lamp and Holder
} RADIOSPARES

NOTE : Nearly all Radio components dealers and most radio and TV dealers stock Radiospares components.

The response of the 'Y' amplifier is linear between 10 and 30,000 c.p.s., the response of the 'X' amplifier (when not used as the time base) being approximately the same.

Circuit Details

The D.C. supply for both c.r.t. and valves is derived from a bridge rectifier connected across the secondary of the mains transformer. The secondary voltage (AC) should be between 300 and 350 volts although a voltage below 300 could be used with some loss of brilliance on the c.r.t.

As the circuit diagram Fig. 1 shows; only two valves are used, one as a 'Y' plate amplifier (V1=EF80 or 6BW7) and the other as a combined time base and 'Y' plate amplifier (V2=12AX7 or equivalent). This is a twin triode with its front half (V2A) switched as either time base or 'X' amplifier with the second half (V2B) used as a phase splitter to feed a symmetrical voltage to the 'X' plates.

The time base is a rather novel one employing a 6.3v. AC drive to V2A grid so that the valve is over driven. Negative feedback helps linearize that part of a cycle used for the actual 'X' scan. The speed of the time base is controlled by the series resistors R7 and R8. For full operation as an 'X' amplifier, the A.C. supply to the grid of V2A is switched off and the anode to grid negative feedback disconnected. The

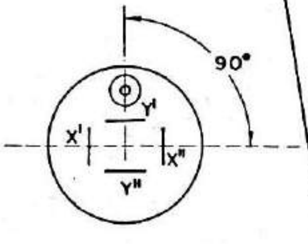


Fig. 3. Orientation of axes of deflection as viewed from screen end.

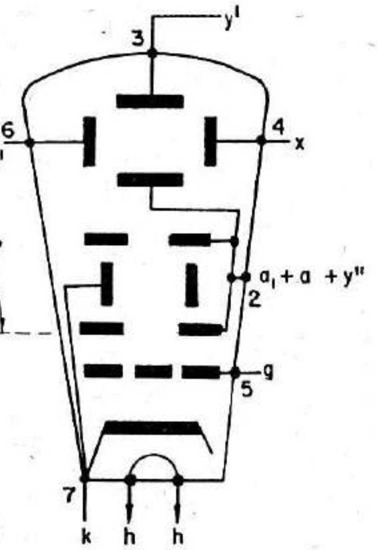
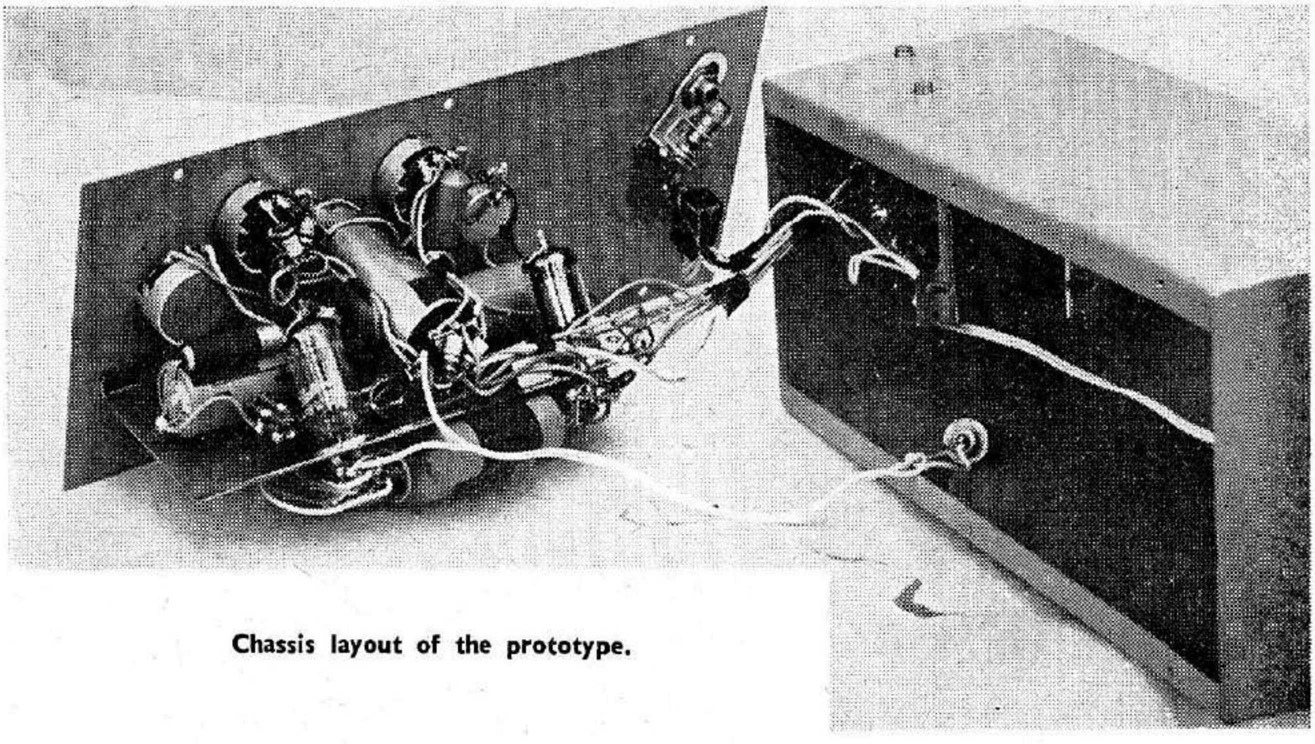


Fig. 2. Connections to the Mullard DH 3–91 Cathode Ray Tube.

50 c.p.s. voltage for both time base and c.r.t. flyback suppression is derived from the heater supply, one side of which must be earthed as shown in the circuit. The cathode ray tube chosen for this simple oscilloscope is the Mullard DH-3-91 which is a one inch diameter tube with internal focus control and which fits a B8G base. (Connections for tube and base are shown in Fig. 2.) (Further details are given at the end of this article.)

NOTE.—*The tube must be orientated so that pin 5 of the base is uppermost as shown in Fig. 3. The 'X' plates will then be in the correct position for horizontal scan.*



Chassis layout of the prototype.

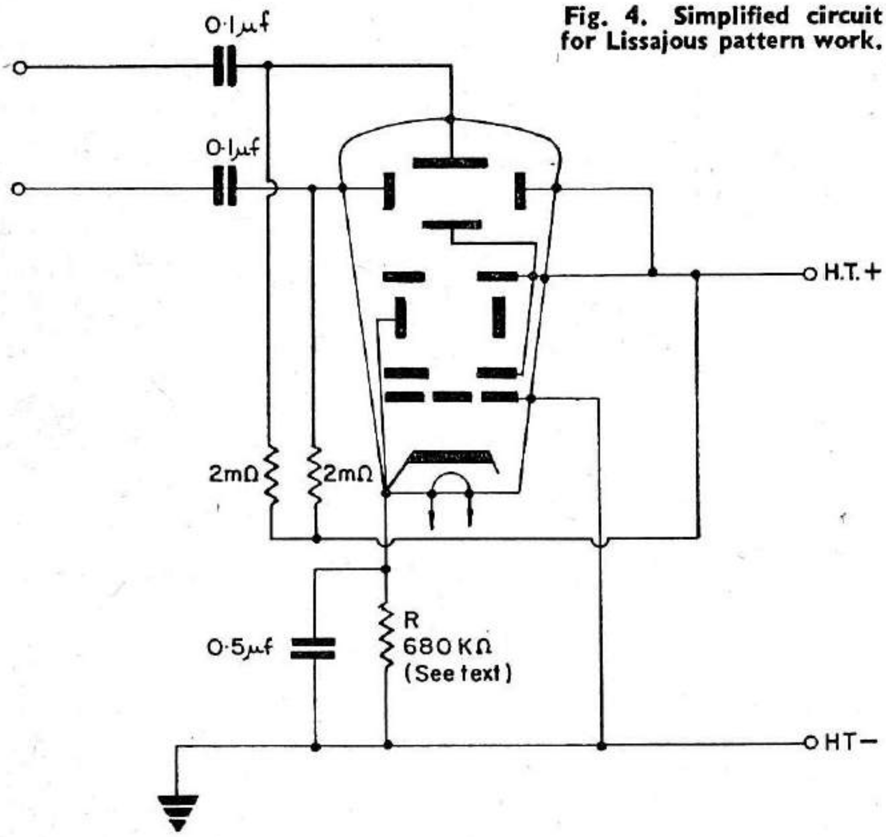


Fig. 4. Simplified circuit for Lissajous pattern work.

An alternative simple circuit (Fig. 4) is given for those who may desire only direct 'X' and 'Y' plate connection for basic Lissajous pattern operation. The cathode resistor R must be adjusted to suit the maximum H.T. voltage and for sufficient brilliance to present a useful display. This resistor could be made variable in which case the value should be about 1 M. ohm for an H.T. voltage of approximately 350 v. The graph of Fig. 5 shows the correct value of resistor for any given D.C. H.T. supply.

Layout and Construction

The layout of the oscilloscope is not critical since the circuits are simple. The mains transformer must, however, be clear of the c.r.t., otherwise induced 50 c.p.s. modulation of the trace or display is liable to occur. The tube could, of course, be fitted with a mu-metal sleeve to obviate this but prevention is always better than the cure. In the prototype model shown in the photograph the mains transformer was mounted about 6 in. from the tube and carefully orientated until no modulation of the spot, or a trace, or a display, was visible.

In the prototype, the valves were mounted one either side of the tube, most of the small components being mounted on tag panels beneath the chassis, with larger components above. The controls were arranged as shown in Fig. 6 and the photographs.

The DH3-91 Cathode Ray Tube

These tubes are made by Mullard Limited and further details are obtainable from Mullard Limited, Mullard House, Torrington Place, London, W.C.2. They may not be directly purchaseable from radio component dealers but a dealer should be able to obtain them without difficulty from his regular wholesaler.

The DH3-91 trace is green and has a medium persistance. The 'X' plates are suitable for symmetrical operation but the 'Y' plates are suitable only for assymmetrical operation. An internal electrostatic system is used for spot focus. The tube may be supported on the base but care should be taken to minimise the effects of shock.

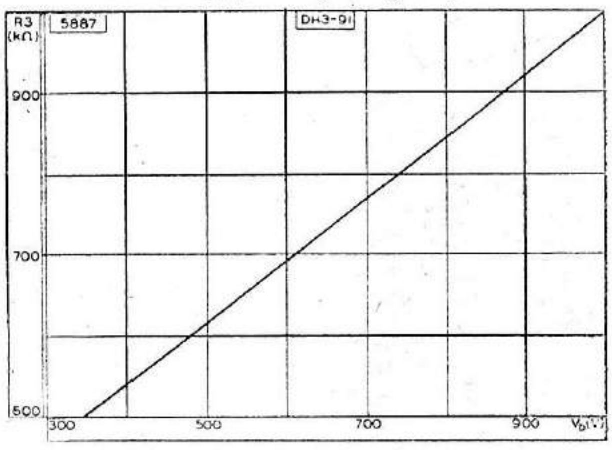
It is unwise to allow full brilliance when the spot alone is displayed as there will be a risk of burning a small dark hole in the screen. Maximum operating conditions of the tube are as follows but note that deflection sensitivity will be slightly greater at the lower operating voltage of 350 as given for the circuit of Fig. 1.

Voltage — A1 + A3 + Yu + 500 volts

Voltage — Grid —8 to —27 volts

(The grid must not be allowed to run positive.)

Fig. 5. Cathode Bias resistor value v. H.T. supply to $a_1 + a_3 + yu$.



Sensitivity 'X'	0.19 mm/v.
Sensitivity 'Y'	0.22 mm/v.
Line width	0.6 mm.

Owing to the presence of a transparent conducting film connected to the anode and which lies between the screen of the tube and the glass, the tube may be operated with its cathode at earth potential without any oscillogram distortion, when an earthed body is brought near the screen.

The prototype oscilloscope performed well and both sine and square waves could be displayed without distortion. The frequency limitation for square waves, is however, approximately 20 c.p.s. to 15,000 c.p.s.

The r.f. input was checked by monitoring a 2 megacycles, 100% modulated transmission of both speech and sine wave. (The photograph Fig. 7 shows the effect of gross over modulation.) The r.f. monitoring facility should be useful to well over 30 Mc/s thereby including such tests as the tone modulation of a 27 Mc/s radio control transmitter. The frequency range of the 'X' and 'Y' amplifiers and the range of the 50 c.p.s. time base are more than adequate for checking tone modulated radio control systems. Frequency comparison by the Lissajous method could be carried out at radio frequencies by using the r.f. input socket for one source and a connection to the one of the 'X' plates, via a 0.001ufd. mica capacitor. If work of this nature is envisaged an additional socket could be fitted and the capacitor permanently connected to an 'X' plate, as has been arranged for the 'Y' input.

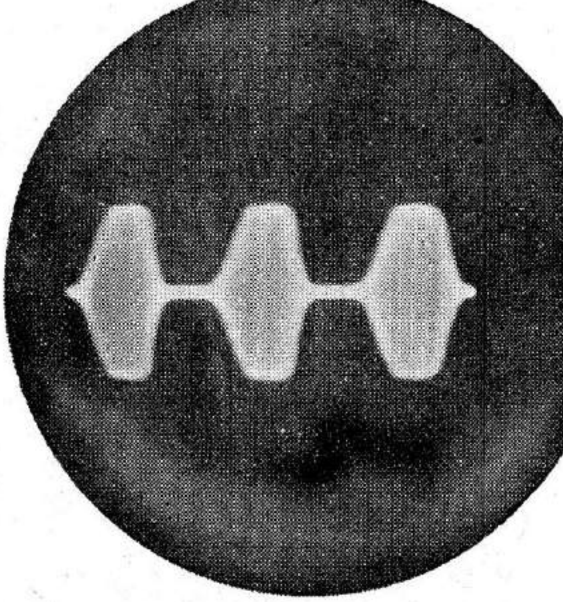


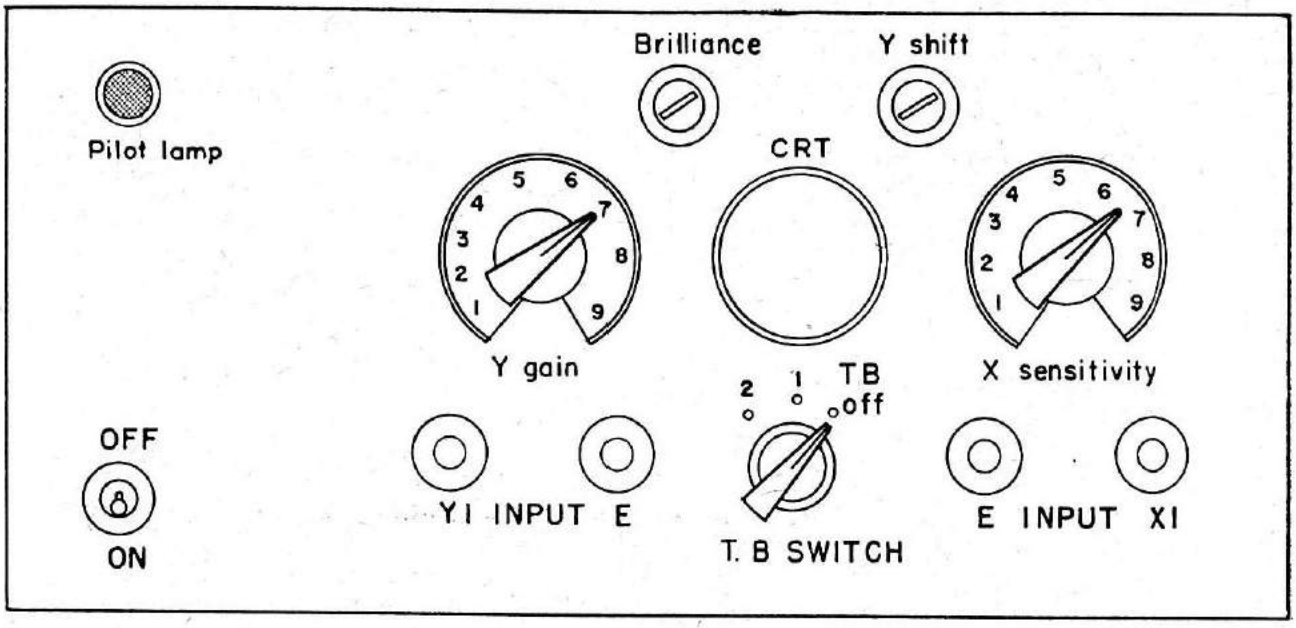
Fig. 7. Gross Over Modulation of an R.F. Carrier of 2 mc/s by a 1,000 c.p.s. sine wave.

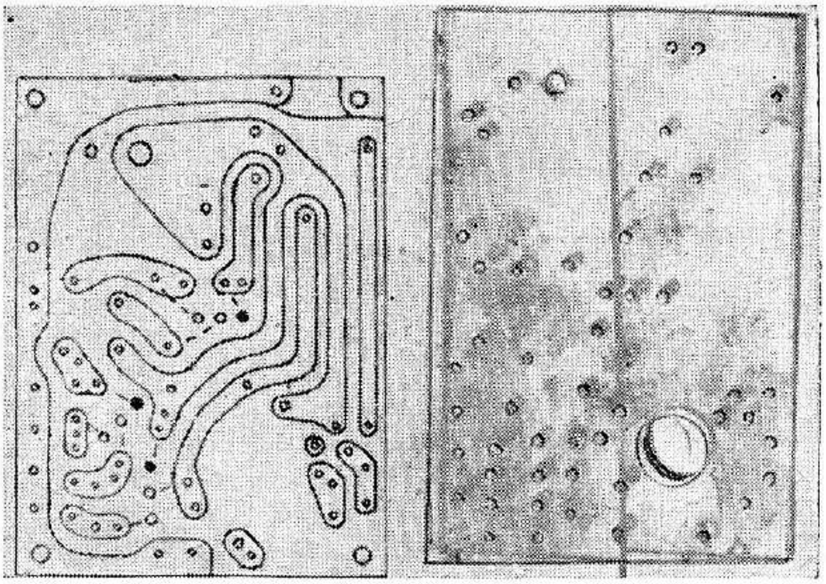
Components

The Brilliance (VR3) and Shift (VR4) controls may be standard type pre-set potentiometers such as those used in television receivers. A panel mounting type should be used so that the small control knob protrudes through the front panel.

The 'X' and 'Y' gain controls VR2 and VR1 respectively are standard type carbon potentiometers and the time base switch is a three-pole, three-way type on a single wafer (S1, S2 and S3). All other components are marked on the circuit diagram and should be readily obtainable from most radio component dealers.

Fig. 6. Panel Layout.





Printed Circuit laid out on paper and mock-up prepared in clear plastic to try out arrangement before transferring to Printed Circuit board.

In response to readers' requests for Printed Circuit information we are offering a precis of an article that appeared in "Aeromodeller Annual" and would acknowledge with thanks excerpts from Paul Runge's Grid Leaks. Sources of supply are also provided.

Printed Circuit Precis

WHAT is printed, or more correctly as we will use it, etched wiring? It is a process for obtaining a predetermined electrically conductive circuit pattern on an insulated base. The insulating part of the base is generally a phenolic paper or epoxy glass laminate with copper foil bonded to one or both sides. Base thickness, for our purpose, is $\frac{1}{16}$ in.

Production of the etched circuit is straightforward. A pattern is placed on the surface to be etched using an acid resistant material. The exposed copper is then etched away using such chemicals as ferric chloride, nitric acid, ammonium persulphate, chromic-sulphuric acid and copper chloride solutions. When unwanted copper is completely etched away, the resist material is cleaned off leaving a copper conductor pattern. Holes are then drilled, components inserted and soldered.

We would advise readers against using nitric acid as an etching medium if they can obtain ferric chloride, since the former is prone to gassing and gives off noxious fumes, so that use in a confined space by unskilled operators would be unwise.

Suitable resists — which is the technical name for the resistant material that protects the parts of the copper foil that we wish to use in the circuit—include wax pencil (Chinagraph), ordinary model aircraft dopes and enamels, beeswax and turpentine mixture, fish glue and albumen mixture, printers' ink, even cellotape well pressed down will answer if need be. All that is basically required is some substance that will resist the etching effects of the solution in use for long enough to get the unwanted copper dissolved and not be subject to any acid creep under the coated surface.

Some questions asked are: How much current will a narrow line carry? What wattage iron should be used? How is material cut and drilled? Using a .0014 in. thick (1 oz.) copper, a $\frac{1}{32}$ in. line will carry about 3 amps., and pro rata. An iron with $\frac{1}{8}$ in. to $\frac{3}{16}$ in. diameter tip rated at from 25-35 watts is desirable. Ersin multicore 60/40 20 gauge solder is excellent. Drilling XXXP material can be done with high-speed drills. Keep drills sharp and use high speed (3/4,000 r.p.m.). Cutting can be done with fine-tooth saw.

XXXP material referred to is official code grading for phenolic paper, and is most widely used grade, with high insulation resistance. There are many other grades such as XXP, which has good punching properties, Epoxy glass, which is the most widely used glass-base type and CE, phenolic cotton, with greater impact resistance than paper bases. However, the ordinary R/C user will be needing only small offcuts for his circuitry, and can be satisfied that supplies are available to him. Just exactly what he is likely to obtain depends on whence the offcuts are derived, but can be accepted as suitable for the work. We have happily made arrangements with our good friends MacGregor Industries to supply an excellent grade of Printed Circuit board at an economic price.

To save etching solution and maintain adequate conductor bond it is desirable to keep conductors as wide as possible and fill in areas that are common to one another. This is dependent on the circuit, since larger areas of copper act as 'ground planes'.

A small flat dish is required to hold etching solution in use—a pyrex baking dish or photo printing dish will do. Ferric chloride (the only solution we will discuss here) is made up of $4\frac{3}{4}$ lbs. per gallon of water plus 1 to 2 ozs. of muriatic acid per gallon. Smaller quantities pro rata. Dissolve in warm water at 100 deg. F., stirring until complete. Etching time will vary from about two-three minutes to 20/25 min. for 1 oz. copper; solution becomes depleted when 6-8 ozs. of copper have been dissolved in a gallon. Throw away solution outside in a hole in the ground—NOT down the drain as it will do the pipes no good.

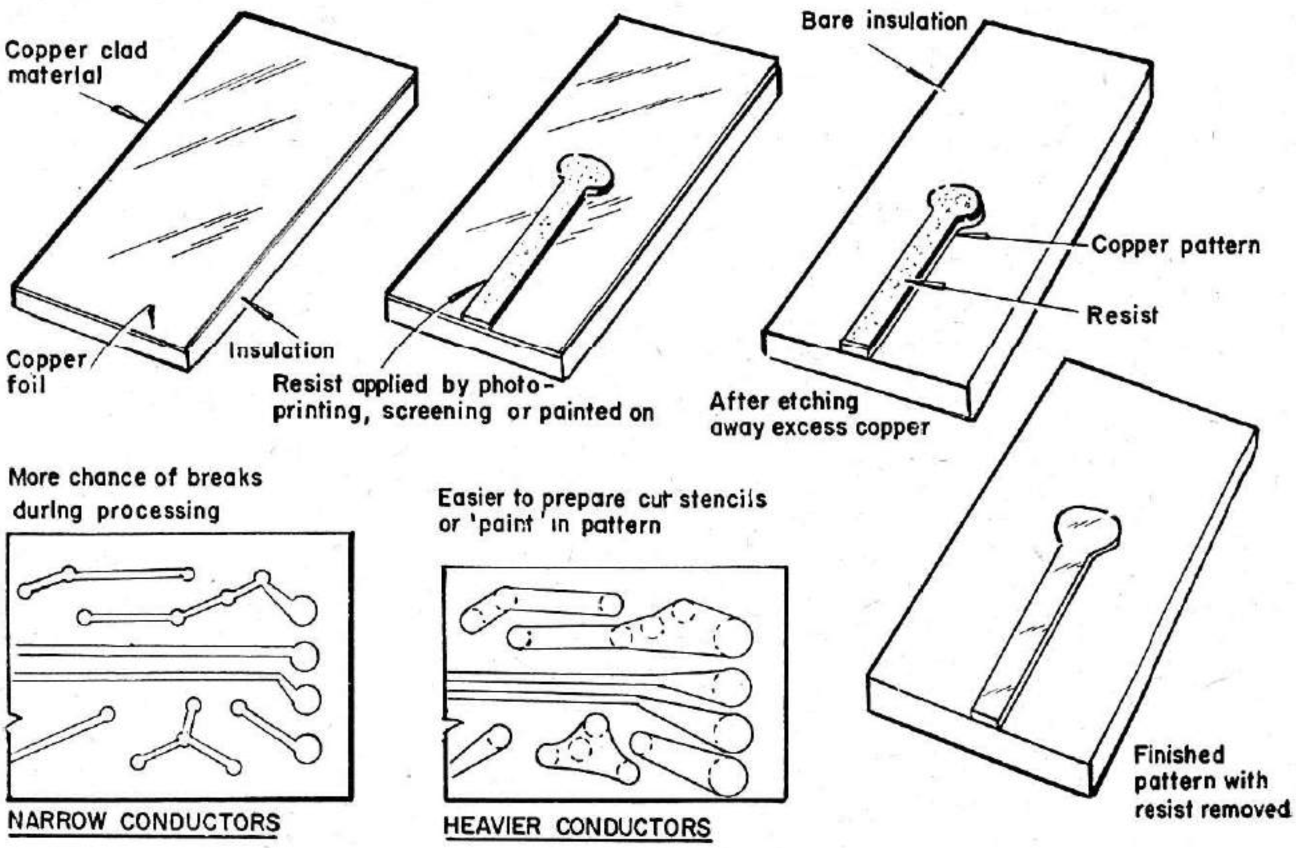
Silk Screening Printed Circuit Boards

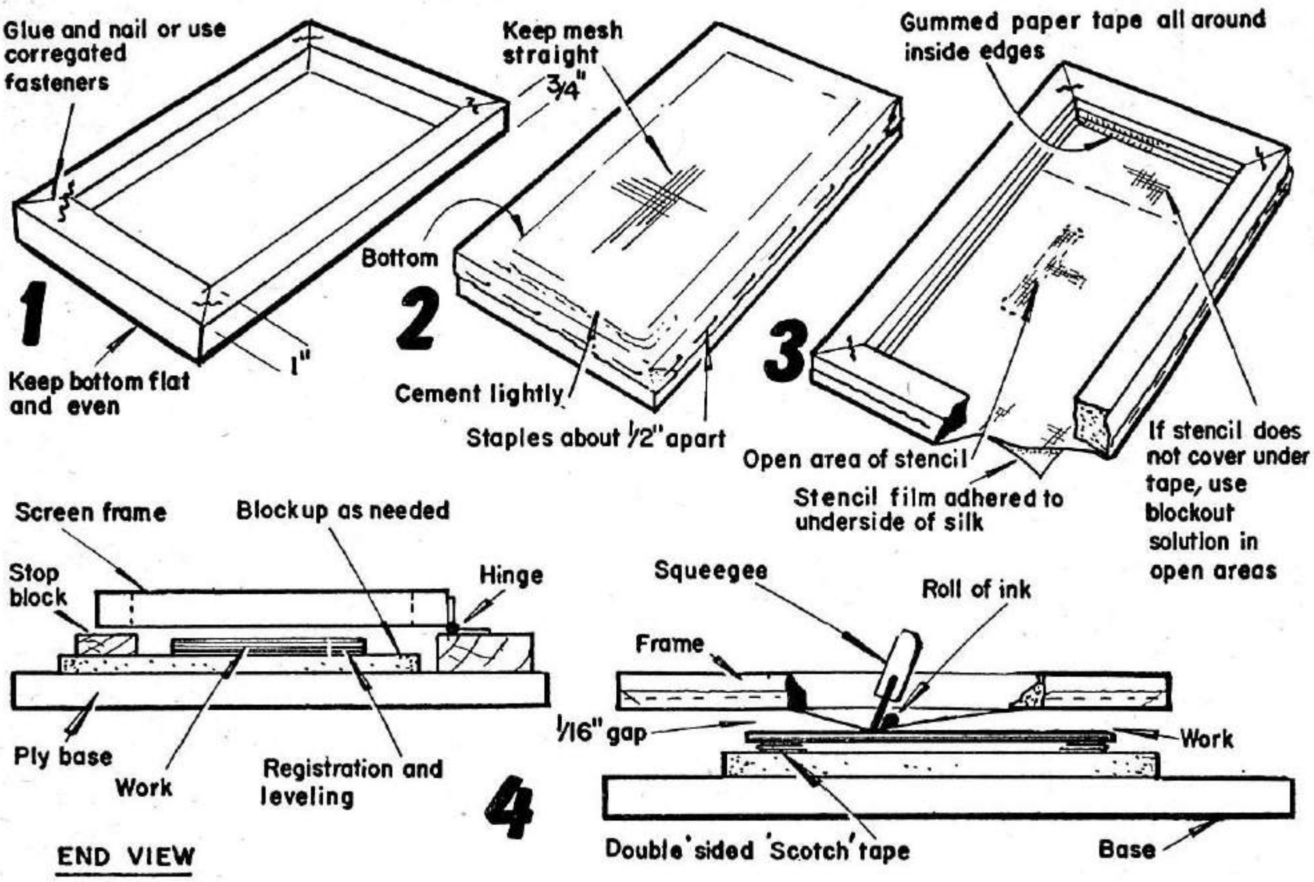
An elaboration of this method, very suitable for club use, involves construction of a simple silk screen printing frame and printing through a stencil. Here the ink (resist material) is forced through a silk screen on to the copper foil covered base.

Special stencil film can be obtained and pattern is cut on it with a razor blade or modelling knife, taking care not to cut right through the backing sheet. Pattern is peeled off leaving background of the film on the backing. Stencil is then placed on several layers of newspapers, silk side up and silk screen pressed on to it, and adhered by following instructions with the stencil film (this may be by adhering fluid or hot iron, according to type). Parts of frame not covered by stencil should be blocked out with special fluid, or simply filled in with paper. Tape in place as necessary with gummed paper tape, not cellophane tape as this is often soluble in inks used.

Base is jigged into position under the screen, and carefully inked through it with a flat type of rubber squeegee. Edge should be straight and sharp. Pull ink once across surface firmly and evenly. A few trial pulls are advised as screen printing is quite an art and

Stages in the preparation of a printed circuit. Narrow conductor layouts are more suited to photographic reproduction.

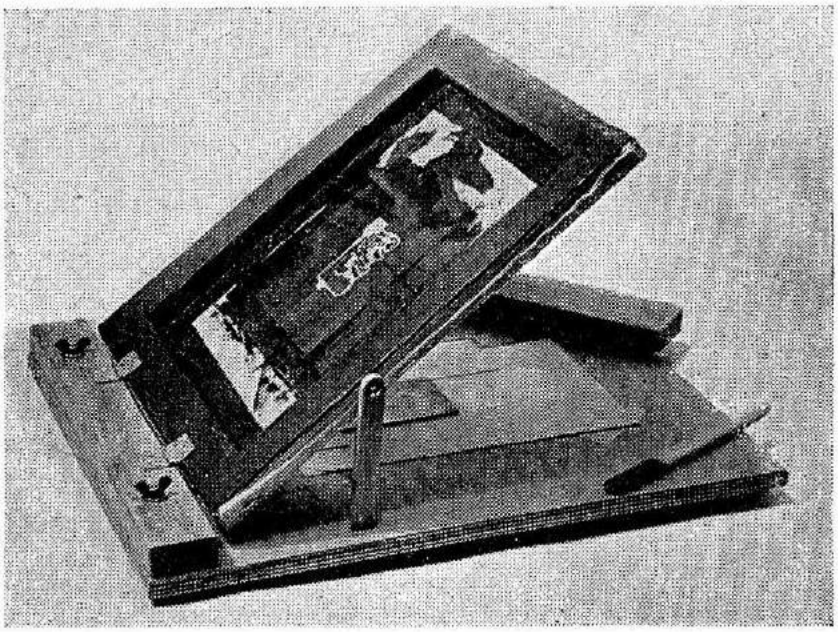




requires practice. Do not be discouraged, therefore, if first efforts are less than perfect.

Many published circuits these days offer a P.C. layout printed full-size, which can be traced down and copied exactly and offers no special problems beyond a degree of patience. For first steps in design the use of squared paper is recommended. In the absence of actual components card cut-outs of exact size can be shifted around for the most economical layout until you satisfied with the basic set-up.

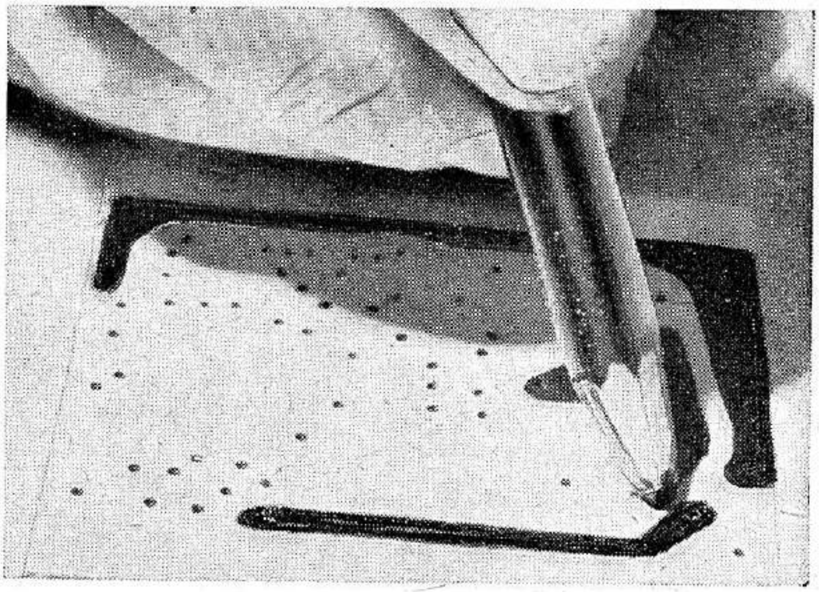
Next design stage, is to find out if the proposed layout is going to work so build a mock-up on $\frac{1}{16}$ in. Perspex using ordinary tinned wire where your etched copper circuit will be *on the lower side only,* remember, as your board is coated on one side only. Here you can drill away and move around to your heart's content without any expense, the beauty of this system being that you can see both sides at once and so will easily memorise the layout later. Connect it up to batteries, even install it in a plane, but do see that it does



Making a simple printing frame for stencil type printed circuits. An old flat bed duplicator can also be pressed into service and will do the job as well if not better.

This Reeves silk screen printing frame solves the problem for those unwilling to spend time making up their own frame. The printing inks supplied with the set also serve as resists.

work *now*. If you find that it is essential to cross two insulated wires use a short jumper wire on the top side for one of them. Remember that in your printed circuit every wire from a component must have its own hole into which to fit, no sharing, so that every part is held rigid at both ends and can be removed without disturbing any other. Mounting all the parts upright close to the base and bending the other wire down to fit into a second connecting hole is the basis of the strength of the system; anything that is longer than the height of the coil-former or the relay/reedbank will have to lie flat. The valve must be held down; clips take valuable space so glueing is better; use a sliver of foam plastic or Elastoplast pliobonded both sides.



Using a Chinagraph wax pencil as a resist. This may not be so neat as stencilling but is as effective.

Once you are satisfied with the performance of the mock-up make an exact size drawing of the layout on paper showing the position of every hole clearly and allowing not less than $\frac{1}{16}$ in. width for each copper strip and a minimum gap also of $\frac{1}{16}$ in. between any two.

Photographic Printed Circuit

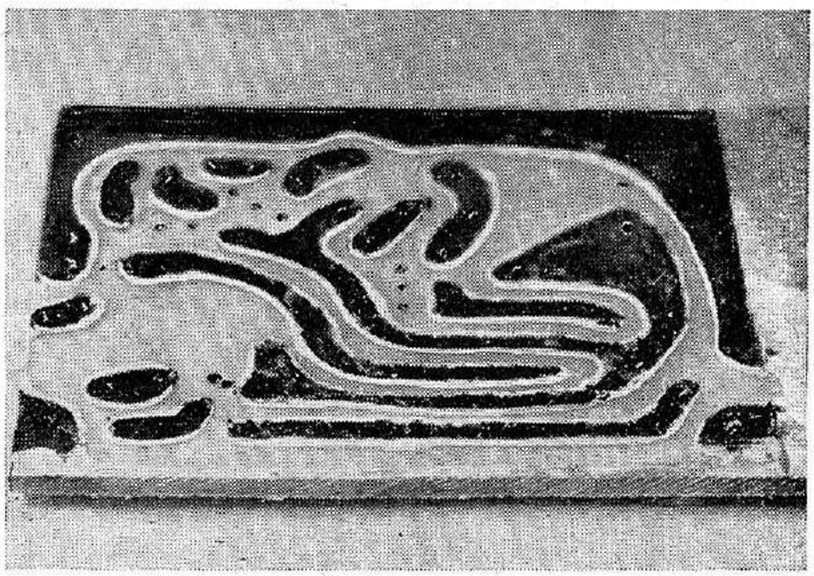
Whilst the crayon, paint and stencil methods of producing PC circuits on board are adequate for average size panels, the increasing trend towards subminiature units makes some photographic means of reproducing the fine detail almost essential.

The process is not difficult to any reader who has done any of his own photographic printing and developing since identical procedures are followed.

First need is a photographic negative, exact size of layout required, for contact printing. If you have no facilities for close-up photography such as this which requires a camera with a ground glass focusing screen, then take your work to the local professional photographer (he may even be a member of the club!) and get him to do it for you. Once made it will serve for ever. The best negatives are made on some such film as Kodalith and you should ask for this if possible. Your layout should be drawn in Indian ink on white Bristol board, preferably at least $1\frac{1}{2}$ or twice full-size. If first laid out on squared paper this enlargement for copying should not be too difficult. Virtue of the bigger drawing is that the larger size makes work less fiddling and minor errors of drawing (no major errors please!) are reduced when picture is scaled down.

Now your photographic experience comes in handy. Prepare your darkroom (bathroom?) as for developing a film, with windows covered to keep out light. A red safelight or darkroom

Completed Printed Circuit board made by the wax pencil method.



CHEMICALS FOR PHOTO PC

KODAK

PC Resist (minimum size 500 c.c.—just over a pint), £1.2.6.

PC Developer (clear or dyebath) (minimum size 500 c.c.), 10/-.

JOHNSONS OF HENDON

Trial PC Outfit:

Magnol L Resist	**1 pt.**	**7/6**
Magnol L Fixer	**1 pt.**	**5/–**
Magnol L Sensitiser	**4 ozs.**	**2/6**

It will probably be necessary to order these items from your chemist. Methods of use will vary between makes and should be followed carefully. Our step-by-step is general procedure only.

PRINTED CIRCUIT KITS

Etch-Your-Own PC 21/- post free. **Proops Bros. Ltd., 52 Tottenham Ct. Road, London, W.1.**

PRINTED CIRCUIT BOARDS

Copper foil (.0014) bonded to grade 1 bakelite base (1/16 in.).

1d. per sq. in. minimum 36 sq. in. 6 × 6 : 3/-) post free. **MacGregor Industries Ltd., Station Wharf, Langley, Bucks.**

lamp can be used, or even a dim yellow one as used for handling bromide paper.

Chemicals required are shown in the "box" Quantities which are minimum that can be ordered may seem large but can probably be shared amongst several interested parties, or bought from club funds and resold.

We must thank our friends *Grid Leaks* for the following steps in preparing the board:

1. Clean board thoroughly, using any of the household powder cleaners and a stiff brush. Board is clean when water will stand on it with no breaks or bubbles.
2. Flow the photo resist onto board until a uniform coating covers the entire surface. A few drops will go a long way. At this stage board must be handled in dim light as above — too bright a light will fog it, and it will all have to be removed and a fresh start made.
3. Still in dim light prop up board in a vertical position until completely dry. Place Kleenex tissue or absorbent towelling under it to catch any excess and avoid a liquid bead along bottom edge of board. Avoid dust at this stage (if not to be used immediately treat just like bromide paper and wrap in several thickness of brown paper and store in drawer away from light).
4. Using an ordinary photographic printing frame, or even a sheet of glass with negative cellotaped on it expose the sensitised board to a photoflood bulb about twelve inches away for three to four minutes (some trial and error may be necessary, but a degree of over rather than under exposure is better).
5. Place the board face up in the developer for three to four minutes agitating the dish. Do not touch face of the board as emulsion is very soft. According to type of developer used image will be visible as a dyed pattern, or if clear developer used then pattern can be seen if board is held at an angle to the light.
6. Hold board under running cold water. This hardens emulsion and washes away unwanted portions. *Gentle* rubbing may now be employed if unwanted parts stubborn.
7. Dry the board with hot air (hair dryer is a good idea).
8. Etch board in ferric chloride as for other methods.
9. Some makers claim their resist is a good solder flux and protective, but if you wish to remove rub off with steel wool.

Cutting PC Boards

Many simple circuits can be laid out in mainly straight lines, so that unwanted metal foil can be *cut* away. The Belgian circuit in this issue is an example. Using a sharp modelling knife and a metal straight edge the whole of this circuit can be cut in about one hour.

Lines should be scored with the modelling knife, the unwanted edge eased up with the point of the blade and then pulled off. It adheres very strongly to the paxolin surface and pointnose pliers are a help in getting it off if sore fingers are to be avoided.

This method is of particular value when producing the simple little boards used for actuating systems, or on-off sequence contacts for energising motors. A colleague has used it successfully for cutting quite intricate shapes including curves and circles, but try to cut away from the fingers or you will splash blood on the work!

A variant is, of course, to cut out the pattern required from foil, scissors can be used here, and then stick it down on ordinary board with Araldite or similar adhesive.

McQUERY COLUMN

DAVE McQUE WILL ANSWER QUERIES THROUGH THIS COLUMN EACH MONTH, AND WE WELCOME GENERAL INTEREST PROBLEMS. AT THE MOMENT WE CANNOT UNDERTAKE TO ANSWER QUERIES THROUGH THE POST, NOR SHOULD SETS BE SENT TO US UNLESS SPECIFICALLY REQUESTED.

I AM contemplating on building the McQue transmitter from your "Radio Models" magazine. I am building this transmitter because I would have more confidence in adding additional units to it than to a commercial unit. As Colonial people it is not always possible to obtain certain parts such as the 2 amp. Neosid inductor.

Am looking forward to your future articles on the "Galloping Ghost".

N. F., MELBOURNE, VICTORIA, AUSTRALIA.

I agree that the "Neosid" choke chores are not readily available and in your country probably unobtainable.

You will find that a television interference suppressor choke stripped and rewound as specified will suit. The size is approx. $\frac{5}{8}$ in. long by $\frac{3}{16}$ in. dia.

DUNDEE and district is a fringe area for T.V. from Kirk-o-Shotts (60 *miles), Kirk-o-Shotts transmits vision from* 53.5 *mc/s*—58 *mc/s, and sound on* 53.5 *mc/s. My problem is that the second harmonic of my R/C transmitter causes vision interference. Within* 100 *yards of a T.V. receiver the effect is 'white out' and up to about* 500 *yards severe 'patterning'. The local boating pond is ringed by residential houses and is unusable during programmes.*

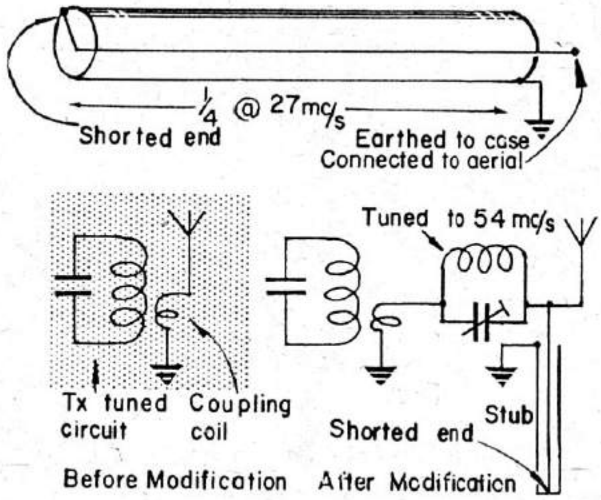
Trusting you can assist.

—J.S.R.L., DUNDEE.

You certainly have a problem as only a minute amount of second harmonic radiation from a 27 mc/s Tx. is required to produce annoying interference in fringe areas of your station (Kirk-o-Shotts).

Firstly it is necessary to ensure that nothing gets out of the Tx. box via keying leads, etc. and this will require the Tx. to be in a metal box and perhaps screening of the keying lead and button besides the usual filter chokes already fitted.

More effective filtering of the unwanted 54 mc/s, signal can be obtained by using a parallel tuned circuit in series with the aerial lead as the effec-



tive output impedance of the coupling loop is small. This in conjunction with a short circuited stub on the aerial side. This stub will be $\frac{1}{4}$ wave at 27 mc/s and $\frac{1}{2}$ wave at 54 mc/s thus it will present an open at 27 mc/s and a short at 54 mc/s.

Now with an air spaced coaxial line the length would be 109 in. = 9 ft. 1 in., but with the solid (polythene) dielectric the length will be about $\frac{2}{3}$ of this, or if you use cable with foamed polythene dielectric, commonly known as low loss fringe area T.V. cable, the multiplying factor is about 0.83.

Make stub a few inches longer than calculated length and reduce $\frac{1}{4}$ in. at a time. Coil up and tuck inside Tx. case. Connect where aerial passes through case.

I HAVE often wondered if a crystal set could be used to operate a relay. If it could, it would be ideal for super lightweight R/C models as there would be no heavy H.T. batteries. Could you tell me if such a circuit is possible and if so, what are its disadvantages?

—D. H., CAPE TOWN.

I would say that even with a high power transmitter the amount of signal available for rectification to operate a relay would be quite insignificant. Even if it were not the relay would have to be extremely sensitive and this would mean large size and weight.

There is also the problem of actuator and battery and in all the weight and size would not be much less than the present subminiature transistor receivers which will work on very small batteries.

In addition there is no gain in the type of circuit described and range would be severely restricted.

I AM thinking of building the 'New Ivy Receiver' in September's issue of RADIO CONTROL MODELS & ELECTRONICS. *Would you please advise me on what actuator to use with the 'New Ivy Receiver' for boat control ?*
G. D., DUDLEY.

Provided the relay contacts and the motor (if any) are adequately suppressed the type of actuator you use will depend upon your requirements as to control and the power required to move the rudder. This, of course, will depend upon the size and power of the boat. Any of the commercial actuators of the correct power will be suitable for this receiver.

I HAVE recently constructed a McQue Versatile Transmitter from a set of parts purchased from Fred Rising. It is not working properly. The current readings with the crystal out and with it in are 3.5 m.A. and 2.8 m.A. respectively, instead of 4 m.A. and 2 m.A. as stated in the instructions. I would be obliged if you could tell me what might be wrong and how I can correct it.
—G. D., BIRMINGHAM.

The first things to check are your batteries. Then the valve (both halves of filament). This assumes that all connections and component values are as specified. Please note that D1 is shown the wrong way round, the RED end should go to earth.

You do not say whether V2 can be tuned or not. It appears that the Xtal is O.K., otherwise the current would not drop at all.

If another valve does not effect an improvement C1, C2 and C3 should be substituted one at a time, also R1, R2, R3 and R5.

I WOULD like to know if you consider the 464 mc/s band for model boats an advantage over the 27 mc/s band ? Also do you know of any firm making radio control equipment which can give any help, details, etc., for 464 mc/s band.—D. K., FLEET.

There are advantages and disadvantages in either band, but I would say that the use of the 465 mc/s band will depend to great extent on the ability of the constructor.

The aerial is certainly much shorter and can be easily fixed on boat, but it is necessary to use special valves and equipment in both the Tx. and Rx. and is recommended only to the expert.

Any of the well-known radio equipment manufacturers would no doubt be pleased to help you and the conversion to radio control is dependent only on the output stages which will be conventional for any type of R/C work.

I AM interested in building the Ivy receiver as described in RADIO CONTROL MODELS & ELECTRONICS *for September, but as it is a very simple set, I wondered what range could be expected when used in conjunction with the transmitter due to appear next month, as I wish to use it in a model aircraft.*
—E. G. H., HALIFAX.

The range of the Ivy receiver with the transmitter to be described was found to be 250 yards plus, with 135 volts H.T. This was ground range and the air range would be many times greater.

A word of warning, however, if you are new to R/C. With any receiver you may get out of range in a strong wind with little penetrating power in your model. This often means underelevating and if there is not sufficient power in the engine the model would dive in a turn.

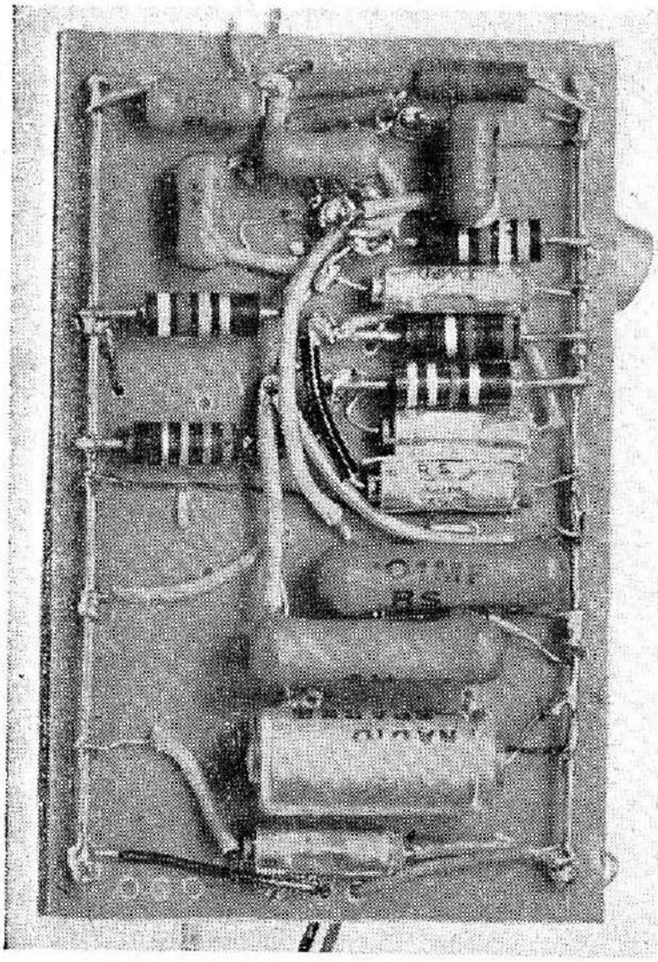
You should have a good penetrating design with plenty of power in your engine underelevate a little. Later on you will find that control of the elevator is of enormous help in penetrating under strong wind conditions.

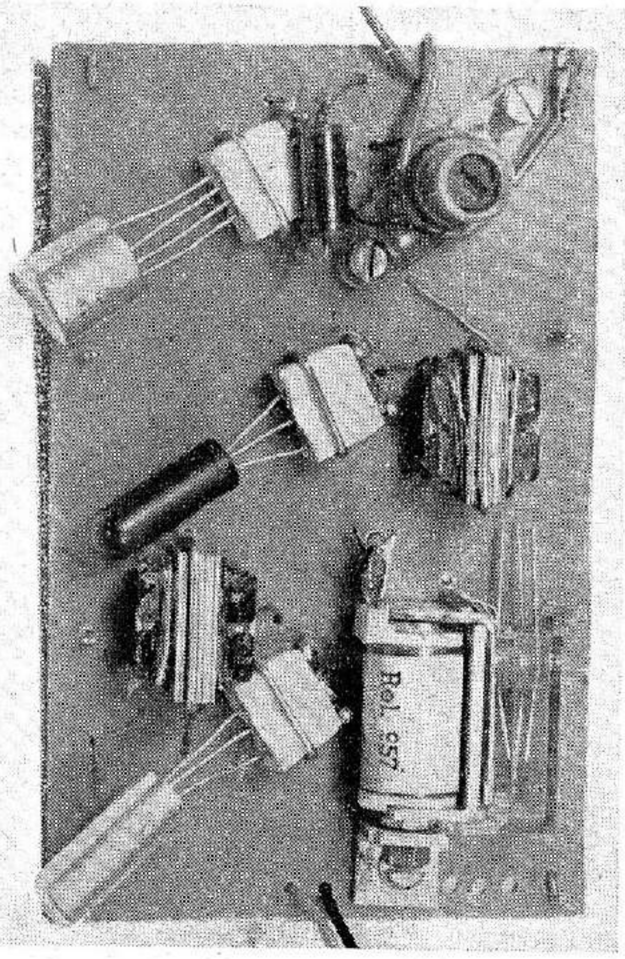
I WISH to insure several radio controlled model aircraft, would you be good enough to give me the address of the insurance company or organization which cater for such a wish ?
P. C., TRURO.

Any insurance company would consider insuring your model aircraft, but you might find the cost prohibitive.

Your best bet is to become a member of the I.R.C.M.S. or a local model aircraft club affiliated to the S.M.A.E. If none locally you could become a country member of the S.M.A.E.

The address is Society of Model Aeronautical Engineers, Londonderry House, Park Lane, London, W.1.





We like the ladder! This tidy layout has captivated us to the extent that we are trying to make all our layouts equally attractive. Long leads on the transistors not to be recommended for flight tests! We are just mean and like to shift our more expensive transistors around.

Circuit Selection

Some of the Circuits which have interested us in the past six months. Offered to the keen experimenter in the belief that further development will be rewarding.

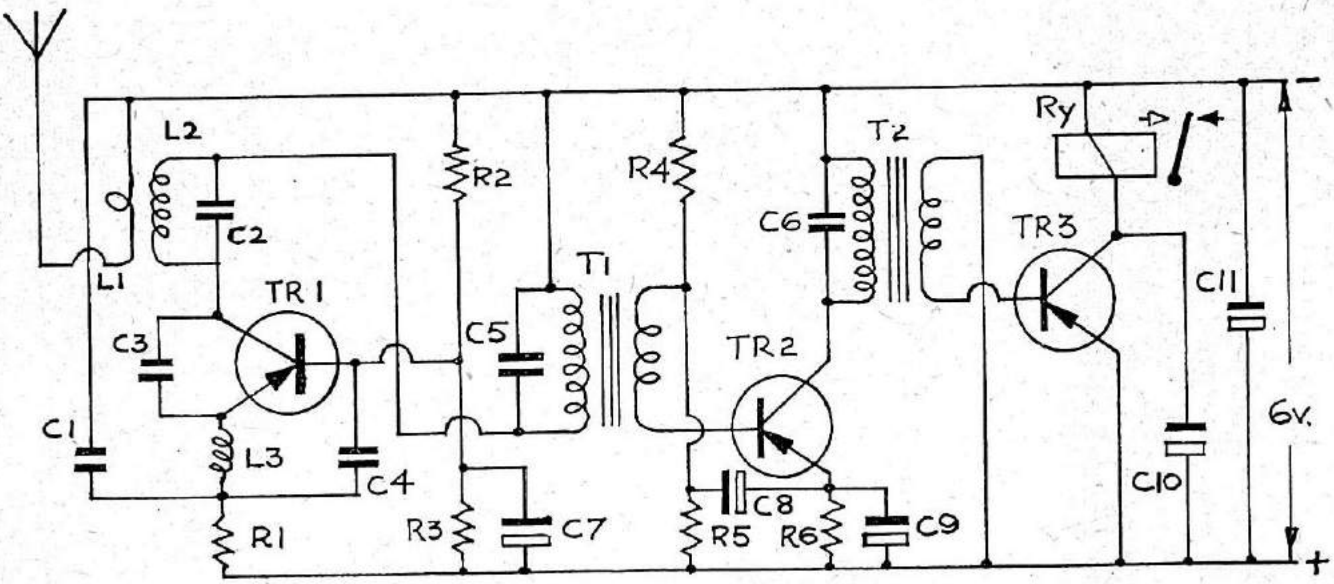
IN the six months since *R.C.M. & E.* first made its bow, we have had the opportunity of looking at a lot of the world's periodical technical magazines, in a variety of languages (not all of which we understand, we hasten to add!). Happily the language of symbols is almost universal so that we have, we hope, derived some benefit from our studies.

Naturally, we tend to accumulate more interesting items than can conveniently be dealt with in full in our pages. Left in the queue to wait their turn their value might be reduced, so we are offering a selection of our recent reading while still comparatively "hot". It must be emphasised that most of these items have not been tested by *us* to finality. Difficulties of getting exact substitute parts may make their construction something of a problem, and in other cases they are offered more for the idea than its execution.

A DUTCH ALL-TRANSISTOR

This appealed first for its designer's sake, since Willy Schoorel is one of Holland's leading R/C fans, next for its variation on the TR 4.5 theme, and finally for its neat and elegant layout, which we have endeavoured to imitate.

FROM the Netherlands comes this interesting variation of the TR 4.5 receiver. It uses only two stages of L.F. amplification, however, but performance is not appreciably affected in spite of this. The design appeared in the March issue of *Radio Bulletin* and we liked it because the components were all nicely



LIST OF COMPONENTS

L 1 2-3 turns 0.5mm. dia. plastic covered.
L 2 12 turns 0.7mm. dia. enam. copper wire.
L 3 RFC 200/500 μ h. Relay 300/500.

C 3 6.8 pf.
C5-6 0.02 μf.
C1 — 4 1000 pf.
C 2 22 pf.
} **Ceramic**

C7-8-9 10 μf 3v. C 10 32-50 μf. 12.5v.
C 11 10 μf. 12.5v.

½ watt

R 1	**2.2 kΩ**	**R 4**	**15 kΩ**
R 2	**47 kΩ**	**R 5**	**3.3 kΩ**
R 3	**3.9 kΩ**	**R 6**	**1 kΩ**

T1-2 Miniature a.f. transformer 4 : 1 ratio.

laid out on the panel and the finished unit had a neat and businesslike look.

A sample was made from components obtained from the various sources available to constructors and after some small modifications it worked like a charm. Range appeared to be all that could be desired.

The transistors specified were OC 170, OC 71 and OC 72 but other types would probably be satisfactory (e.g. SB 305) provided a series resistor of say 10K. is included in the collector circuit of the RF transistor to limit the volts where necessary.

A Gruner relay of 300 ohms resistance was used in the output stage and with 4.5 volts a change of 15 m.A. was obtained on signal. As the relay contacts make at 8-10 m.A. this was considered ample. Incidentally although 6 volts is specified in the design the OC 170 was quite satisfactory on 4.5 volts.

As with all super-regenerative receivers (valve or transistor) some juggling with components was necessary in the RF stage to get maximum results. The circuit as published in *Radio Bulletin* is given and the mods. are as follows:—R1 was reduced to 1.5K. This might be varied up or down but not less than 1.2K. L2, The best value was found to be 15 turns of 28g. enamelled copper wire. C2, 5 pf. was found to be ample. It even worked well without a capacitor. C5 and 6, .01 mfd. was found to be satisfactory.

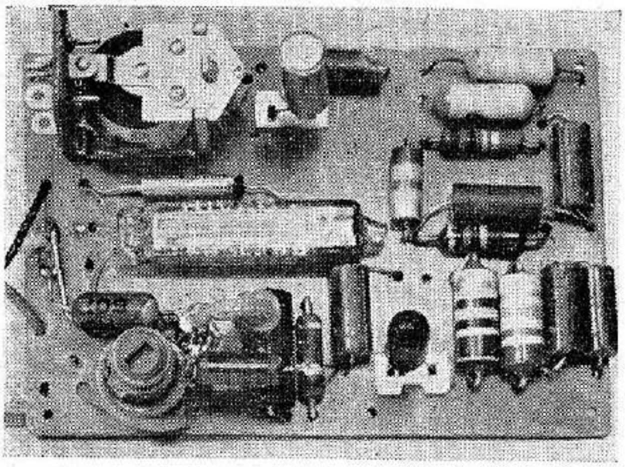
The original layout provided for soldering the transistors in position but for ease of testing holders were used. If the constructor feels confident to solder the transistors in place without damage this is obviously the best method. A good transistor, however, is quite satisfactory and the transistors can be held in place with a narrow strap.

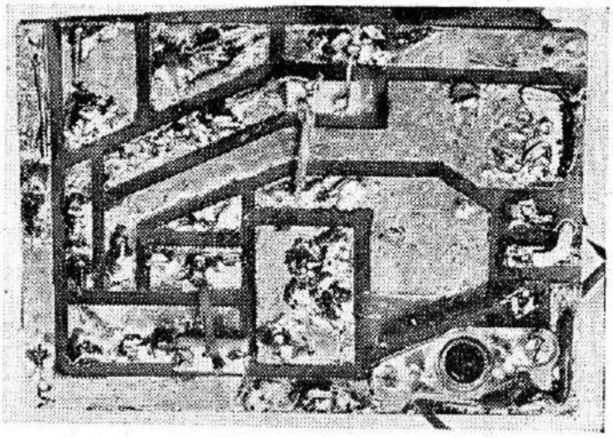
Resistors and capacitors were obtained from "Radiospares", transformers and transistors from "Henrys" and the relay from Ed. Johnson. H.F.C. is our old friend "Neosid choke core" obtainable from "Denco". It is wound full with 40g. enamelled copper wire.

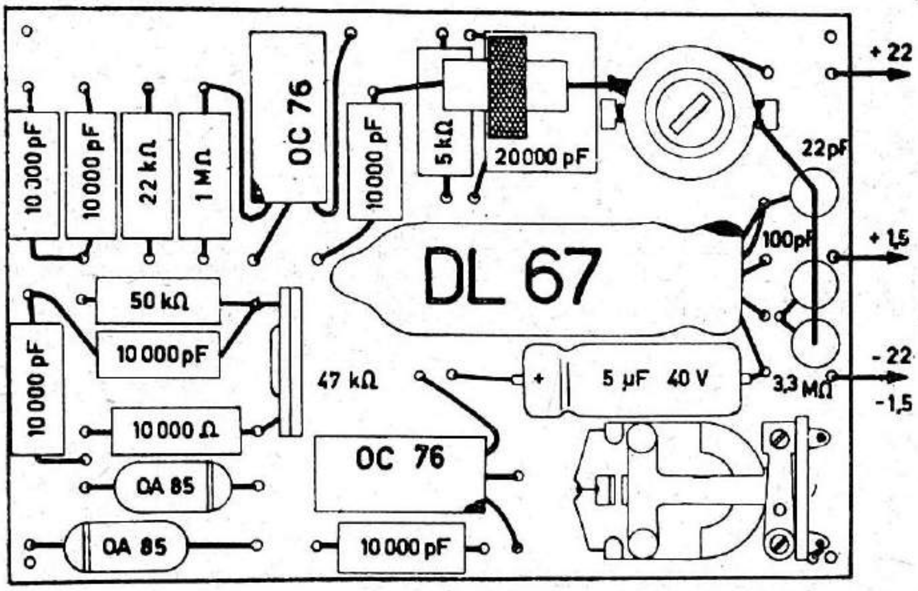
M22—A BELGIAN P.C.

This set made a special appeal in view of our interest in simplified P.C. work. If for no other reason then it is worth trying as an exercise in cut-and-tear-off procedure.

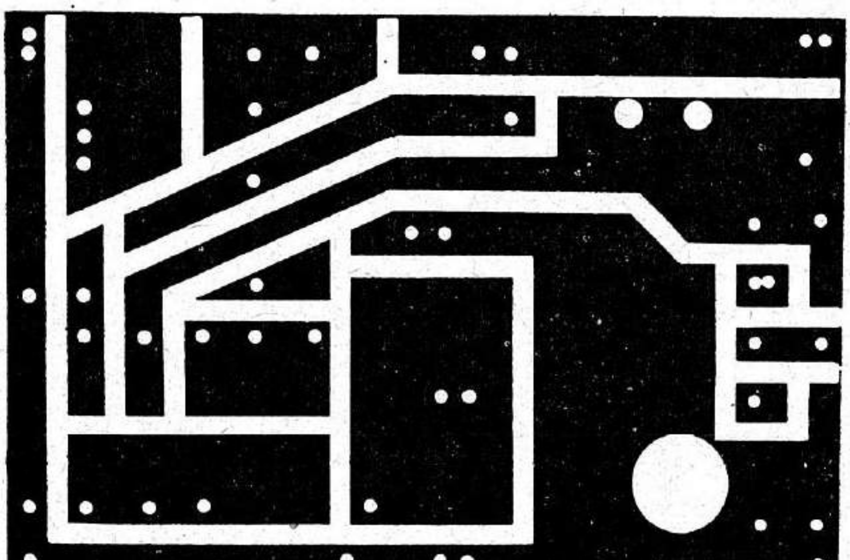
HERE is an interesting receiver from the Belgian magazine *Model-Avia* which whilst reminiscent of the "Aerotone" has a different approach and includes an arrangement for adjustment for reception of carrier only. It also includes printed circuit technique which makes assembly very easy.







It will be noted from photos that we have made use of transistor holders instead of direct wiring, hence some untidy "jumpers" are visible, and transistor location has been adjusted. DL67 valve is not available in this country though still to be obtained on the continent. Suitable alternative is XFY 34 or for U.S. readers 6007.



P.C. panel is full-size. It took us about one hour start to finish to cut. Panel was first transferred in pencil using dividers and ruler, then scribed with a modelling knife, point inserted under start of parts to be removed until a corner big enough to be gripped with pliers. Pulling off with fingers is hard work and gets them sore! Drill after cutting.

It is emphasised however that it is not for the beginner. The circuit as printed did not function efficiently with the components obtained and some "fiddling" was necessary before reasonable results were obtained. It offers a challenge to the experimenter and can produce excellent results when the problems which arise have been solved.

On carrier only a current fall of about 1.5 m.A. can be expected but on tone a rise of from 2 to 4 m.A. depending upon efficiency, can be achieved.

For carrier work the 47K pot. should be included in order to adjust operating conditions. For tone it can be replaced with a fixed resistor. Several were tried and 4.7K. was found to be most suitable.

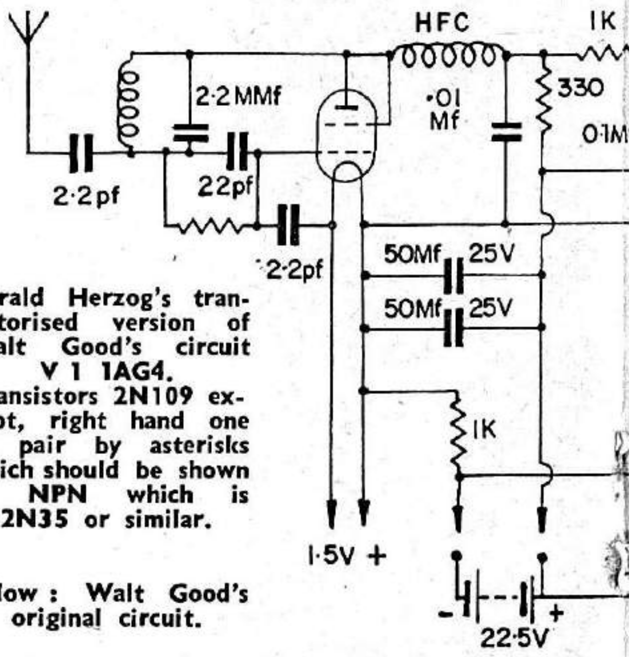
The original circuit is shown in Fig. 1 and the variation to suit our components is given in Fig. 2. It is the valve circuit which needs modification and values can be anything from 22pf. for the grid capacitor and 1 meg. ohm for the grid leak to 100pf. and 4.7 meg. ohm. The tuning coil with the centre tap was replaced with the type shown and the turns increased to 20 with a 5pf. capacitor across the winding. This could be varied to obtain optimum results. The object is to obtain maximum sensitivity in the valve stage and the amplifier does the rest.

Apart from this the only other alteration was to vary the 10,000 pf. (.01) capacitor in the feedback network in the output stage. It was found that an increase to .1 mf. gave some improvement.

Relayless Version

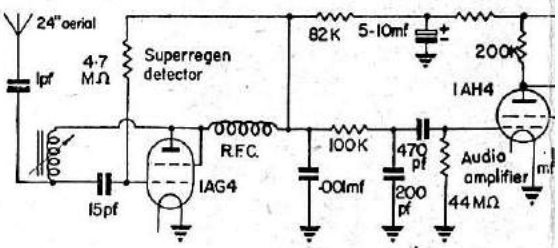
It is possible to replace the sensitive relay by another OC 76 transistor, when one can get 200 m.A. rise with a 4½ v. battery, which is sufficient for a correctly mounted escapement. With the receiver adjusted for modulated waves (tone TXs) the resting current of a second stage rises from .4 to 2.5 m.A., which will make the third transistor a conductor through which a current of 25 to 150 m.A. passes according to the resistance of the escapement. One can obtain thus a sub-miniature receiver, very light, which is suitable for an aircraft with .8 c.c. motor, since the whole of the radio equipment weighs less than 1 oz.

There is some criticism of the layout. This could be improved by removing the output stage from the vicinity of the valve circuit.



Gerald Herzog's transistorised version of Walt Good's circuit V 1 1AG4. Transistors 2N109 except, right hand one of pair by asterisks which should be shown as NPN which is 2N35 or similar.

Below : Walt Good's original circuit.



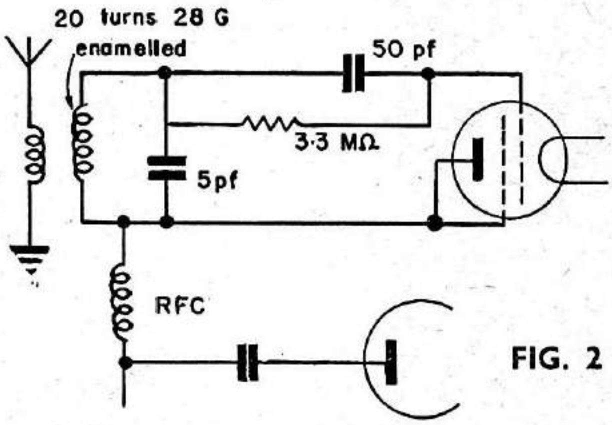


FIG. 2

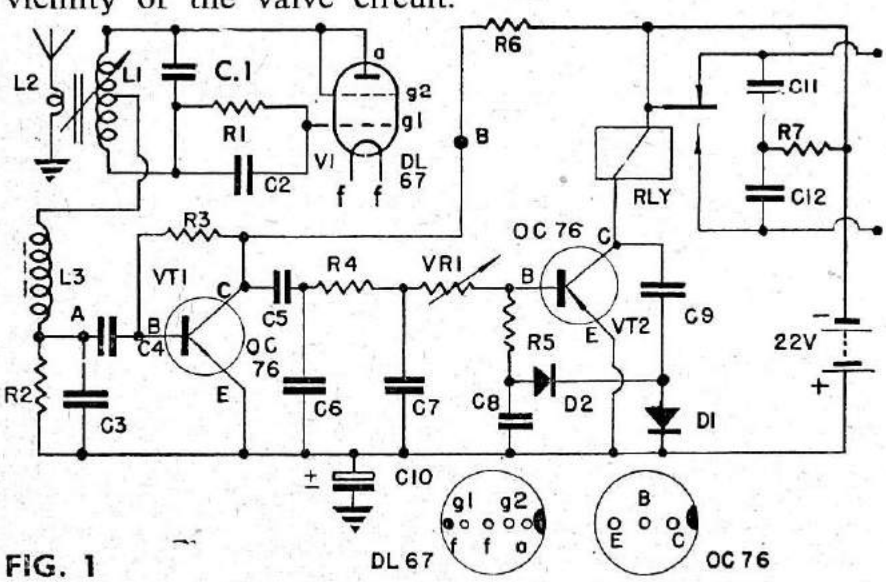
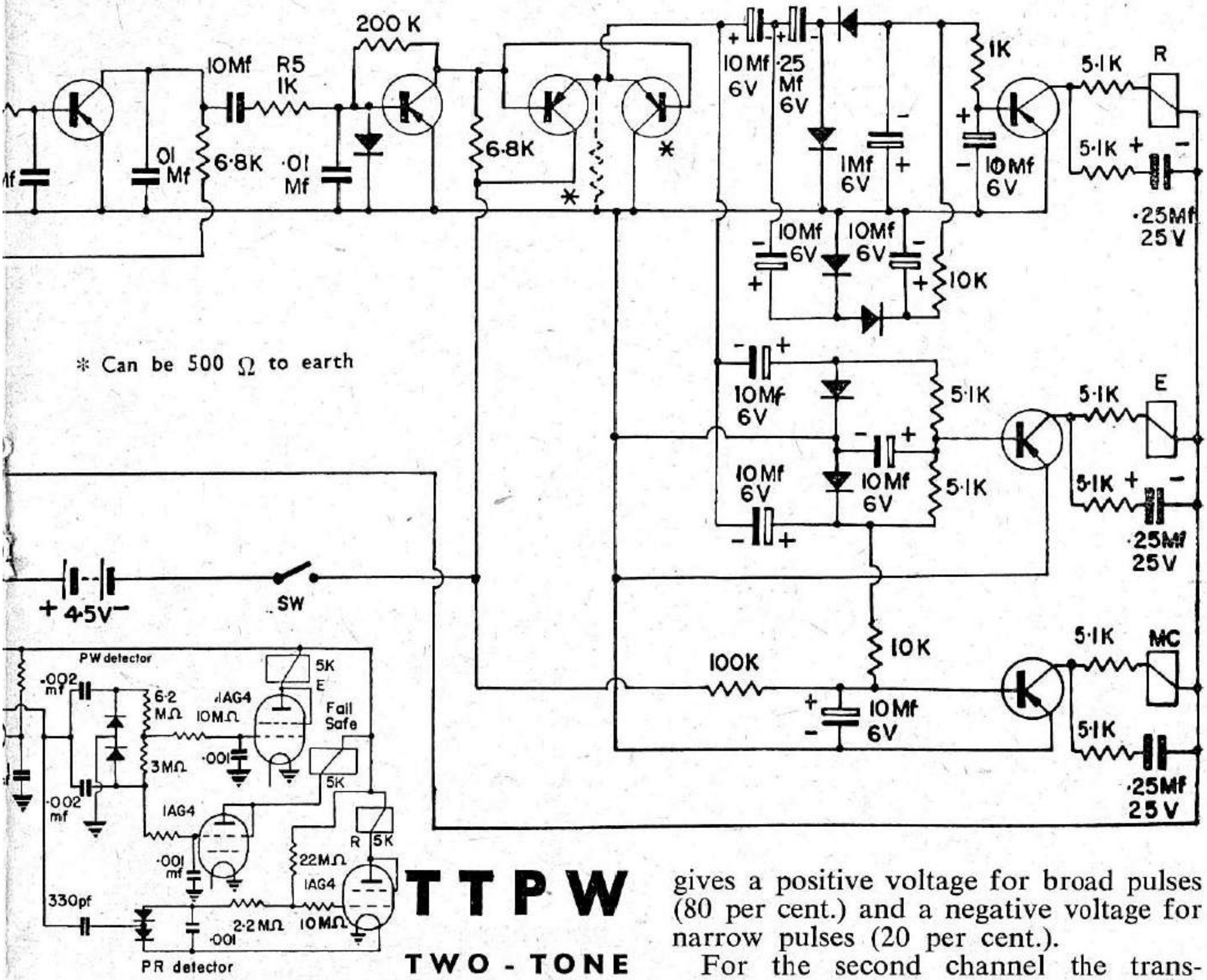


FIG. 1 DL 67 OC 76

C1 22 pf.	R1 3.3mΩ
C2 100 pf.	R2 5 kΩ
C3 20,000 pf.	R3 1 mΩ
C4/9 10,000 pf.	R4 50 kΩ
C10 5 μf.	R5 10 kΩ
C11/12 10,000 pf.	R6 22 kΩ
VR 1 47k Ω	R7 50 Ω

Points A & B are first and second stage testing points during assembly to which headphones with a 10,000 pf. capacitor should be connected which should enable progress to be gauged.



T T P W

TWO - TONE PULSE WIDTH

DR. WALT GOOD'S FAMOUS DUAL PROPORTIONAL

DR. WALTER A. GOOD needs no introduction to the radio control enthusiast and his T.T.P.W. (two tone-pulse width) system is also familiar to us all. It is not a simple system but is so outstanding that we could not fail to include it in our pages.

Credit must be given to the original idea in an article by H. H. Lawson, junr. (Q.S.T. Feb. 1952).

One channel is obtained by transmitting a square wave modulation which is varied in order to produce unequal parts for signal on and signal off. The proportion selected is 80/20 and 20/80 and these proportions are switched back and forth at approximately four times per second. The switching time is varied in order to obtain full proportional control. A pulse width detector gives a positive voltage for broad pulses (80 per cent.) and a negative voltage for narrow pulses (20 per cent.).

For the second channel the transmitter modulation is switched from 100 c.p.s. to 500 c.p.s. The switching is in the same manner as that for pulse width (i.e. 80/20 and 20/80).

The pulse width detector ignores frequency changes and only responds to pulse width variations.

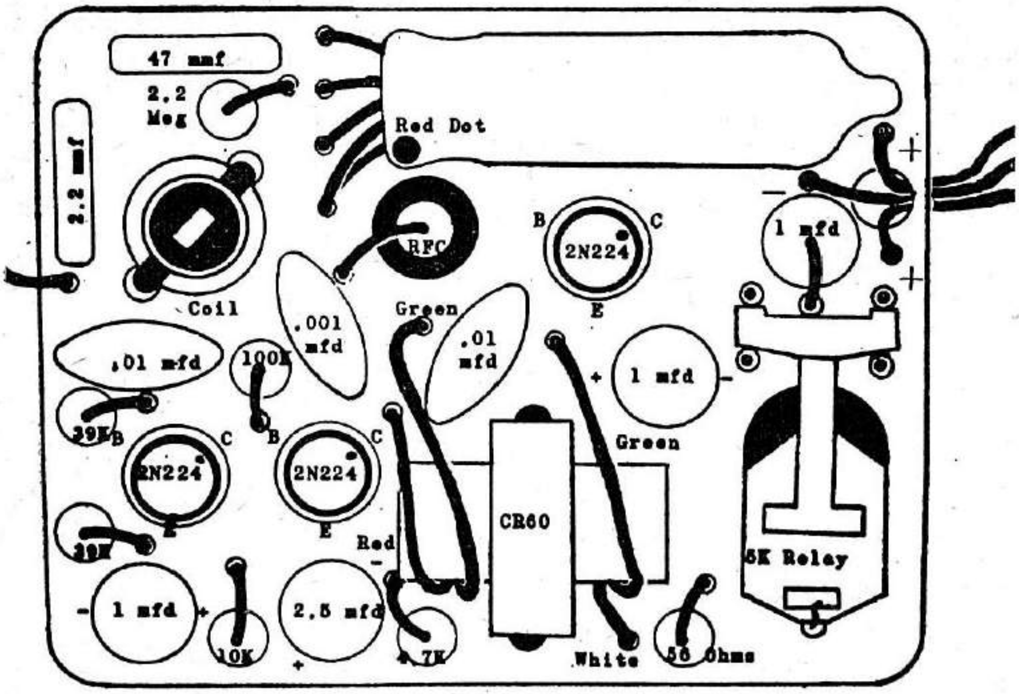
The pulse rate detector responds to frequency changes only giving a negative voltage for high tone and little or no voltage for low tone.

Two completely independent channels are thus available for rudder and elevator and the rate of switching is such that flutter is hardly discernible.

The system also includes a fail-safe circuit which centralizes the servos on no signal or full signal.

The complete receiver circuit is given together with a transistorized version developed by Gerald Herzog (American Modeler, December, 1957).

Walt Good's system was first described in January/February, 1957 (American Modeler) and is still the finest dual proportional system for the experimenter.



L 1 36 turns 30 s.w.g. on ¼ in. P.C. type former.

RFC Miller Type 6152 20 μ h.

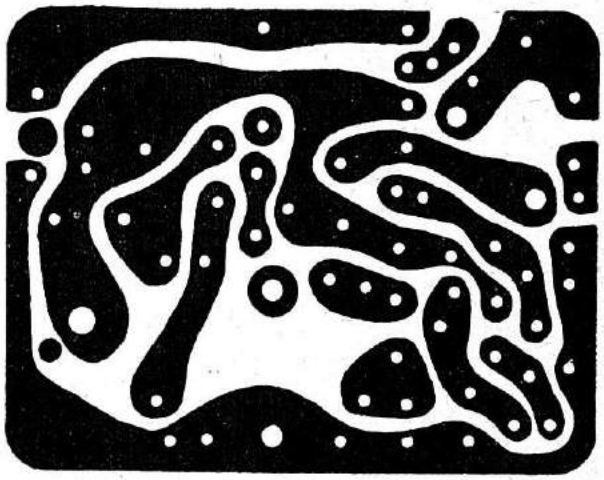
T1, T2, T3 Philco 2N224.

V 1 6007.

Electrolytics : Plug in P.C. type.

Component layout is oversize — the P.C. board is full - size. Should there be problems of getting suitable miniature components there is no reason why board should not be scaled up slightly.

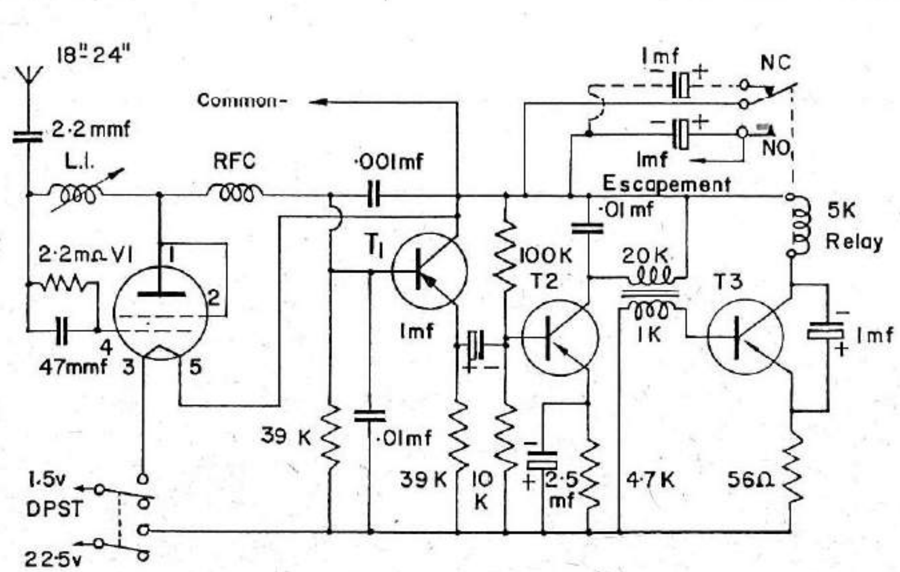
IMPROVED KRAFT SINGLE AUDIO RECEIVER



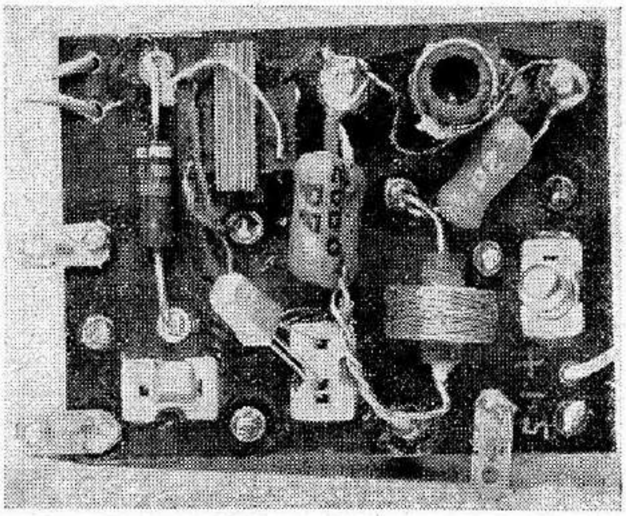
THE original Kraft Rx. claimed to be most successful assembly kit set in the U.S.A. K.L.M. pilot we met at Dubendorf mad keen about it, claims to assemble one nearly every evening he is at home for friends—all work wonderfully. Latest version, for which, as so often, we are indebted to GRID LEAKS, is even better, and seems a "must" as another P.C. exercise. Board shown is ready for copying, by hand, stencil or photographically. Good luck!

Designer Phil Kraft of California produced this revised layout so that P.C. capacitors could be used and the much lighter Dean's relay substituted, plus a few additional features. It now features:

1. Far greater sensitivity ; 2. Will follow the very highest pulse rates ; 3. Uses new high quality transistors ; 4. New circuit makes for greater ease of assembly ; 5. Uses Dean's lightweight relay ; 6. Uses plug-in type electrolytics for easier assembly.

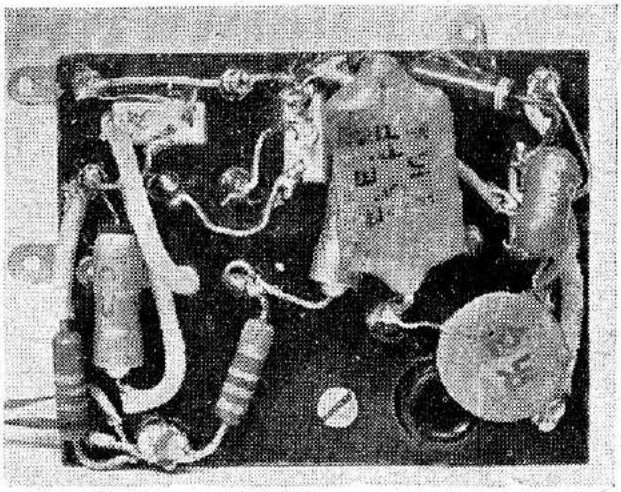


To tune the receiver it is necessary first to plug milliammeter at the B plus lead. Tuning the Rx. to the carrier will quiet or still the meter needle vibration. Meter current, without signal, is generally in the neighbourhood of 0.9 to 1 m.A. Upon receipt of signal of the carrier, this will be quieted considerably and will also show a steady characteristic. With receipt of a modulated carrier of at least 100% in a range of 400 to 1,000 c.p.s. the relay stage will rise to approximately 4 m.A. This will depend on varying characteristics of the valves and transistors used, but, in any case, the action will be sufficient for good solid relay action.

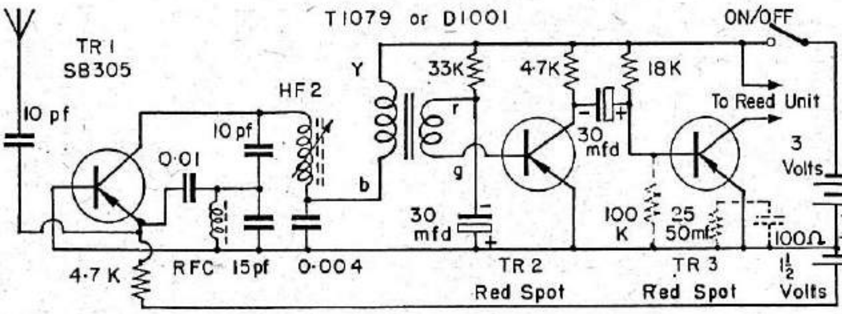


HENRY'S TRANSISTOR RX.

This tiny little set is the cheapest (50/-) all transistor Rx. on the market in kit form. It is round about match box size, 2 in. by 1½ in., and seemed an exciting project to try. We understand that hundreds of these kits have been sold and all degrees of skill in builders are a having a go, from Howard Boys who has been playing with the circuit for some time to the schoolboy who sent his set to Dave McQue for help in the last stages.

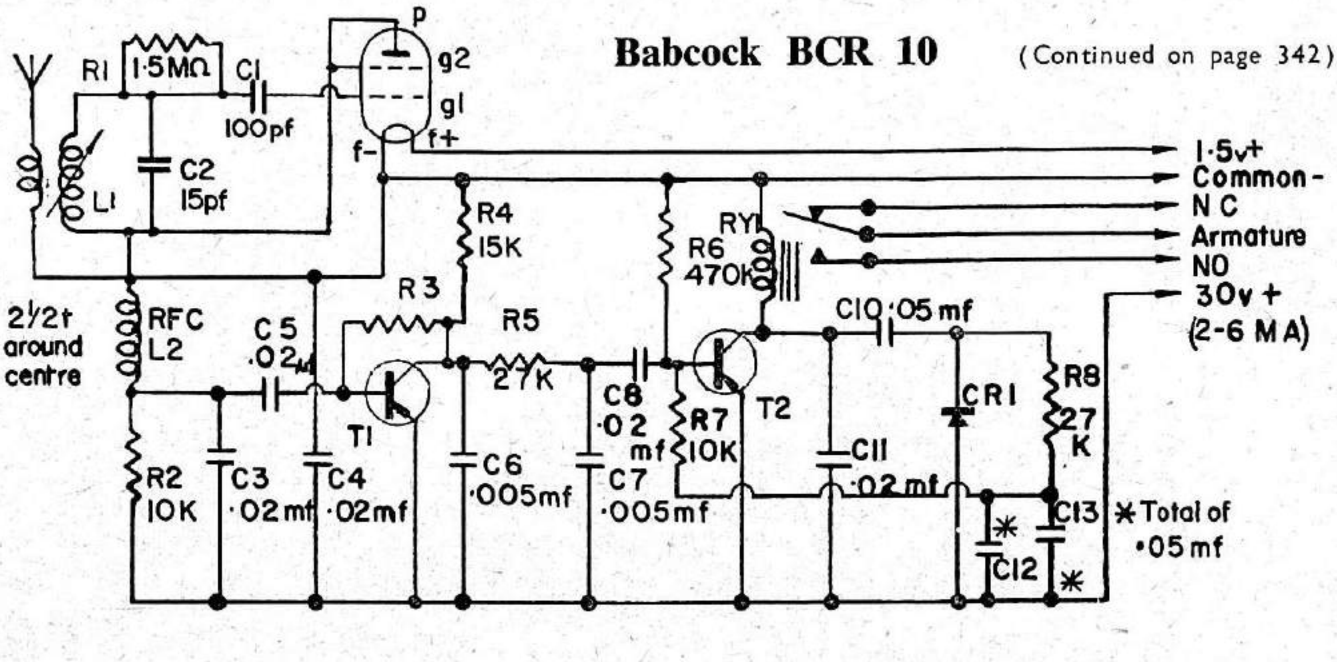


We would say at once that it is not really a set for the beginner but offers considerable interest to the middle stage enthusiast and expert. The circuit is interesting and worth some time spent developing it. At the price of 50/- it obviously cannot include high gain transistors, if these are substituted better results can be expected, though such experts as Dave McQue consider the addition of a further stage desirable. However, there it is, we hope you enjoy playing with it as much as we did.



Babcock BCR 10

(Continued on page 342)



This Rx. we first noticed in French *Radio Pratique* described by Robert Matthieu. Some details of components were missing which R.M. could not provide. We wrote Babcock Models—then in process of being reorganised by the Brothers Eck — without immediate results, and eventually got the U.S. details from the files of Howard McEnte. Frankly, we have not obtained the performance evidently obtained by the original kit product, but th circuit is interesting enough to pass on. Meanwhile the new Babcock-Eck Company (which is not now making this particular Rx.) has offered us one of their present sets in return for a sub, and this is now in process of coming through the Customs. We will report on it in due course.

CONVERSION TABLE

These metric equivalents of standard wire gauge sizes, expressed both as diameters and cross sectional areas in millimetres and inches should be of assistance to our international readership in interpreting circuits and component lists to their local supplies.

SWG No.	*Wire diameter sheet thickness* inch	mm	*Wire cross-sectional area* inch²	mm2	SWG No.	*Wire diameter sheet thickness* inch	mm	*Wire cross-sectional area* inch²	mm2
0	0.324	8.229	0.0824	53.190					
1	0.300	7.620	0.0706	45.603	21	0.032	0.813	0.0008	0.5189
2	0.276	7.010	0.0598	38.597	22	0.028	0.711	0.0006	0.3972
3	0.252	6.400	0.0498	32.176	23	0.024	0.610	0.00045	0.2920
4	0.232	5.893	0.0422	27.272	24	0.022	0.559	0.00038	0.2380
5	0.212	5.385	0.0352	22.772	25	0.020	0.508	0.000314	0.2025
6	0.192	4.877	0.0289	18.678	26	0.018	0.457	0.000255	0.1645
7	0.176	4.470	0.0243	15.659	27	0.0164	0.417	0.000211	0.1362
8	0.160	4.064	0.0201	13.035	28	0.0148	0.376	0.000172	0.1109
9	0.144	3.658	0.0163	10.507	29	0.0136	0.345	0.000144	0.0931
10	0.128	3.251	0.0128	8.301	30	0.0124	0.315	0.000128	0.0826
11	0.116	2.946	0.0105	6.818	31	0.0116	0.295	0.0001057	0.0681
12	0.104	2.642	0.0085	5.480	32	0.0108	0.274	0.0000916	0.0591
13	0.092	2.337	0.0066	4.288	33	0.0100	0.254	0.0000785	0.0506
14	0.080	2.032	0.0050	3.243	34	0.0092	0.2337	0.0000665	0.0428
15	0.072	1.829	0.0040	2.627	35	0.0084	0.2134	0.0000554	0.0357
16	0.064	1.626	0.0032	2.075	36	0.0076	0.1930	0.0000454	0.0292
17	0.056	1.422	0.0024	1.254	37	0.0086	0.1727	0.0000363	0.0234
18	0.048	1.219	0.0018	1.167	38	0.0060	0.1525	0.0000283	0.0182
19	0.040	1.016	0.0012	0.8107	39	0.0052	0.1321	0.0000212	0.0137
20	0.036	0.914	0.0010	0.6567	40	0.0048	0.1219	0.0000181	0.0116

Next Month . . .

ON SALE 10th NOVEMBER

HIGHLIGHTS OF THE ISSUE INCLUDE:

RESISTANCE CALCULATOR — Handy card cut-out that requires no mathematics ★ All Transistor Tone Transmitter with high efficiency tuned aerial ★ Sqd. Ldr. Sarll's "Monitor" All Transistor Matchbox PC Receiver ★ Peter Lovegrove on Simpl Simul for Beginners and Special Simpl Simul Servos ★ Warship Pyrotechnic Circuitry ★ Modulation Technique ★ Basic Principles of Radio Control ★ New Equipment McQuery Column ★ Test Report on Reptone Tx. and Rx. ★ Here, There and Everywhere.

Basic Radio

PART I: FUNDAMENTALS

By G. E. DIXEY

This new series is intended for the raw beginner who needs to re-learn (or acquire) the background to radio electronics without which so much that is simple appears hard to understand.

Basic Concept of Electricity

MODERN theory has it that the flow of electricity through a conducting material is the movement of very minute negative particles known as electrons. It is sufficient for a basic understanding of the circuits that follow to neglect the origin of these electrons. We can say that they are present in all materials, but that in a conducting material they can be made to flow through the material more easily than they can in an insulator.

Units

The Coulomb and the Ampere

It is because the electron is such a minute quantity that we need a larger, more practical unit and so we have the coulomb, the unit of quantity of electricity equal to 6.29×10^{18} electrons. We shall not use this unit very much, but it is a good thing to be familiar with it. The unit which is of real interest is the ampere, which is the rate of flow of electricity. If we can imagine a length of wire with a battery connected across the ends, and if one coulomb of electricity flows into one end of the wire, and out of the other end in every second of time, then we say that the rate of flow of electricity is 1 coulomb/sec. = 1 ampere.

The ampere is rather large for radio work, so we have a unit equal to a thousandth of an ampere known as the milliampere (written mA.), and an even smaller unit the micro-ampere (written uA.), equal to a millionth of an ampere. In common parlance these units are the amp., milliamp., and micro-amp.

The Volt

In the same way that we must have pressure to force a flow of water through a pipe, so we need some electrical pressure to cause current to flow through a conductor. The pressure is measured in volts, and may be supplied by a dry battery, accumulator or a generator to quote the general sources. This pressure is termed the electromotive force (e.m.f.) of the battery, etc.

We have also smaller units, the millivolt (mV.) and microvolt (uV.), which are a thousandth and a millionth of a volt respectively.

The Ohm

Mention was made earlier of the ease with which electrons can be made to flow through a conductor as compared with an insulator. Actually, the opposition to the flow of current, exhibited by various materials varies considerably being very high for rubber, glass, bakelite, etc., these being good insulators, and very low for copper, gold, silver, aluminium, etc., these being good conductors. In order to compare the various materials we must have a unit of opposition (or resistance as we shall call it from now on), and this unit is the ohm (written Ω).

We can define the ohm very simply for our purposes by saying that if the current through a conductor is 1 amp. when the voltage across the conductor is 1 volt, then the resistance of the conductor is 1 ohm. Values of resistance in radio are usually very high, so we need other units, the kilohm (written kM. or M.), equal to a million ohms.

Ohms Law

Here we meet one of the fundamental relationships in electricity, and one which we shall use very often.

In the simple circuit of Fig. 1 a battery B of 1 volt sends a current of 1 amp. through a resistance R of 1 ohm. If we now increase the value of B to 2 volts, the current rises to 2 amps., and if then to 3 volts, the current becomes 3 amps.

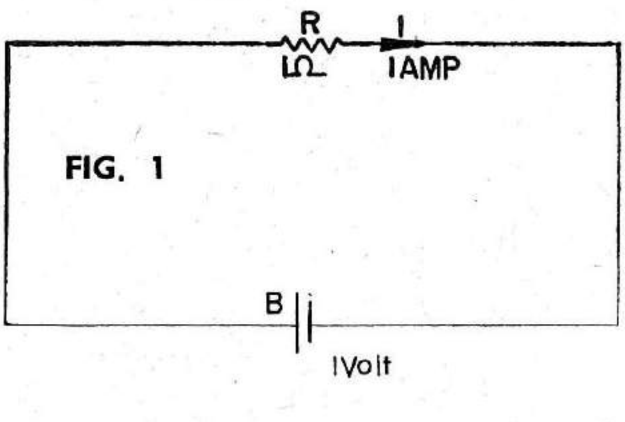


FIG. 1

In each case voltage=current × resistance. Denoting voltage, current and resistance by V, I and R respectively:—

$$V = I \times R.$$

or simply $V = IR$

This relationship always holds good, so that if we know any two of the quantities V, I and R we can find the third.

Because $V = IR$ and $R = \frac{V}{I}$

$$I = \frac{V}{R}$$

Power

When current flows through a resistance energy is used up in overcoming this opposition to the flow of current. The rate at which this energy is used is known as the 'power' dissipated in the resistance. To determine its value we can use one of the following three formulae:—

$$\text{Power } (P) = VI \text{ watts}$$

$$P = I^2R \text{ watts}$$

$$\text{or } P = \frac{V^2}{R} \text{ watts}$$

These relationships can be derived from Ohms Law, and' enable us to find the power dissipated, knowing any two of the factors V, I and R.

One final word, when performing calculations on electric circuits, we must always insert in the formulae the basic units, the volt, the amp, the ohm, the watt, etc., otherwise we shall get the wrong answer.

As an example, if we have a resistance of value 3.3 K., and a current of 200 uA. flowing through it, and it is required to find the voltage across the resistance, then K must be converted to ohms and uA. must be converted to amps. to find the answer.

$$V = IR$$

$$= (200 \times 10^{-6}) \times (3.3 \times 10^{-3})$$

$$= 0.66 \text{ volts.}$$

Had we not converted our units the answer would have been 660 volts!

Kirchoff's Laws

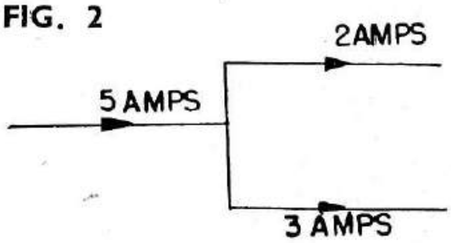
Two important, but simple, laws which we should know are those due to Kirchoff. They are:—

1. The algebraic sum of the currents at a junction is zero.
2. The sum of the individual P.D.'s in a circuit is equal to the applied e.m.f.

Looking at law (1) first (Fig. 2) we see that all it boils down to is that if an electric current flows into a junction, the currents flowing away from the junction when added up equal this current.

So that if at the junction in Fig. 2 currents of 2 amps. and 3 amps. respectively flow out of the junction, the current flowing into the junction is 5 amps.

FIG. 2



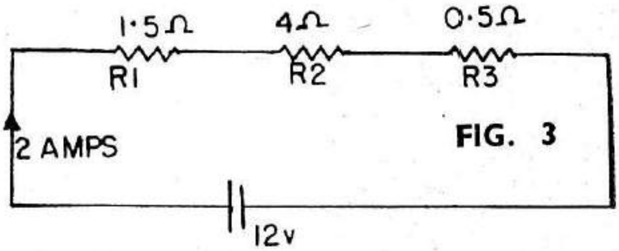


FIG. 3

We have a battery whose e.m.f. is 12 volts and it is sending a current through three resistances in series. Now Ohm's law tells us that $V = IR$, therefore the voltage drop (or potential difference) across

$$R_1 = 2 \times 1.5$$
$$= 3 \text{ volts.}$$

$$\text{P.D. across } R_2 = 2 \times 4$$
$$= 8 \text{ volts}$$

$$\text{and P.D. across } R_3 = 2 \times 0.5$$
$$= 1 \text{ volt}$$

$$\text{Sum of the P.D.'s} = 3 + 8 + 1$$
$$= 12 \text{ volts}$$
$$= \text{e.m.f. applied.}$$

CONTACT SPRING PRESSURE

(Continued from facing page)

sq. in. Spring temper nickel silver has a limit of proportionality of approximately 45,000 pounds per sq. in.

Adopting phosphor bronze as a standard choice, and assuming that the material available may not always be in the fully spring-tempered state, the standard formula can be reduced to:

$$P = \frac{9{,}000\, b\, t^2}{L}$$ for phosphor bronze springs, whence:

$$t = .01 \times \sqrt{\frac{LP}{b}} \text{ approx.}$$

Contact Spring Pressure

By R. H. WARRING

CONTACT spring pressure is widely regarded as an arbitrary requirement, yet has a considerable bearing on the design and performance of light duty contacts. In most cases, actual contact will take place between relatively few spots or projections and contact resistance is largely independent of nominal contact area. With an increase in contact pressure the effective area of contact increases because of the deformation of localised high spots and so electrical resistance decreases.

The graph shows a typical performance with flat contacts under different contact pressures, the decrease in contact resistance with increasing pressure being most marked. Obviously with flat contacts, the higher the pressure that can be employed the better, although this must be limited by practical considerations as to the geometry and mechanics of the system, and the strength of the contact spring material.

Maximum available contact pressure available from a flat strip contact spring can be calculated quite readily from the standard formula for stress and deflection of a cantilever beam. Where the spring departs from a simple, consistent beam form, however, practical results are not always consistent with theory. For general solutions, however, with straightforward spring shapes, calculated maximum contact pressure can be determined with good accuracy by assuming that the maximum stress in the spring material does not exceed 80 per cent of the limit of proportionality of the material. Alternatively, as a simpler approximation, maximum material stress can be taken as 40 per cent of the ultimate tensile stress of the spring material.

The standard beam formula then reduces to—

$$P = \frac{bt^2S}{15L}$$

where b = width of spring in inches.
t = thickness of spring in inches.
L = cantilever length of spring in inches.
S = maximum tensile stress of spring material in pounds per sq. in.
P = Maximum contact pressure available from spring, pounds.

This formula then gives the maximum contact pressure which can be obtained consistently from a flat spring of given dimensions and material. If set to a higher spring pressure then the spring material is being overstressed and contact pressure will not be maintained.

Suitable fixed factors in design are usually the length (L) and breadth (b) of the spring, when thickness (t) required for a given maximum contact pressure can be calculated for a particular spring material.

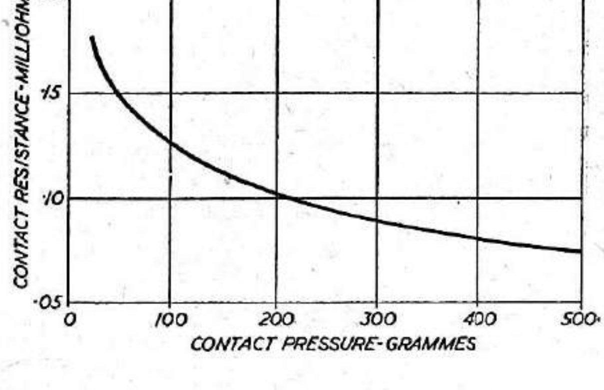
$$t = \sqrt{\frac{15\,LP}{bS}}$$

Where the theoretical thickness required is not available, adjustment can be made by amending the width (b) or length (L) dimensions, if necessary. Maximum contact pressure is directly proportional to spring width, thus an increase in spring width increases the contact pressure, and vice versa. Maximum contact pressure is inversely proportional to length and thus a decrease in spring length gives an increase in pressure available, and vice versa.

The choice of spring material is relatively limited. The best materials are those with a high limit of proportionality, which virtually restricts the range to spring tempered phosphor bronze or beryllium copper. The former has a limit or proportionality of approximately 70,000 pounds per sq. in. and the latter 100,000-110,000 pounds per

(Continued on facing page)

FIG. 1. Variation of contact resistance with contact pressure, based on Johnson, Matthay & Co. data.



Modulation Technique . . .

FOR SIMULTANEOUS MULTI-CHANNEL CONTROL

By

H. CUCKSON, A.M.Brit., I.R.E,

Who will provide a short series of articles to clear up some common misunderstandings on the subject and introduce interesting new circuits. It is intended for the "middle range" of enthusiast who will be well repaid for careful study of the theory.

IN the past few years, the skill demonstrated by the leading exponents with aerobatic radio controlled model aircraft has reached unprecedented heights, so much so that a newcomer not possessing simultaneous multi-channel control in his equipment would be at a grave disadvantage in trying to emulate their achievements.

It has been the writer's experience, in discussions over the years with modeller and R/C equipment designers, that many are ignorant of the fundamental principles of modulation, and demodulation, a knowledge of which surely must be essential to the design of reliable equipment. In the past a logical case has been made for the simple methods of modulation used in some commercial equipment because it was the cheapest and simultaneous control was not in vogue, but such methods are unsuitable for today's requirements.

In this article which deals briefly with the principles of modulation and demodulation as it affects remote control enthusiasts, mathematics will be avoided as far as possible, but important equations must be stated for emphasis. For rigorous proofs, the reader is requested to refer to any good text book or the works of reference 1, 2.

Principles of Control

The general method of control in use at present is that various tones are generated in the transmitter. In the receiver the various tones are fed to a series of filters which discriminate between the various frequencies present and the output of each filter is used to actuate a switching device. The filters in use may be one of three forms:

(a) The ubiquitous tuned reed.

(b) The increasingly popular tuned LC filter.

(c) The lesser known electronic filter which uses a C.R. network (e.g. a bridge T) in conjunction with a valve or transistor.

All the discriminations have one factor in common, i.e. they only respond to their particular fundamental frequency, so that any other frequencies present in the output of the receiver, i.e. harmonics, cross modulation products, noise, etc., are redundant information and constitute wasted power. It is therefore desirable that only the pure sine waves are generated in the transmitter and are not distorted in the process of modulation.

Modulation

The general equation for a sinusoidal carrier wave is $e = A \sin (\omega t. + \phi)$. ($\omega = 2\pi$ x the carrier frequency and ϕ is the phase angle) .... equ. 1.

The intelligence may be conveyed by the carrier by modulating it in any one of the three ways.

1. Amplitude .... variations in A.
2. Phase .... variations in ϕ.
3. Frequency .... variations in ω.

We are only concerned with the first method since phase and frequency modulation are not really permissible with the band widths available and their techniques are more involved.

Next consider a sinusoidal modulating signal B sin pt (where $p = 2\pi$ x modulating frequency), then when modulated the carrier amplitude becomes $A + B \sin pt$, so that the equation to the modulated carrier wave becomes $e = (A + B \sin pt) \sin \omega t$. This may be written as $e = A\left(1 + \frac{B}{A} \sin pt\right) \sin \omega t$, where $\frac{B}{A}$ is called the modulation factor M, and if distortion is to be avoided M must not exceed 1, which is 100%, so that $e = A (1 + M \sin pt) \sin \omega t$ which when fully expanded becomes

$$A \sin \omega t + \frac{MA \cos}{2} (\omega - p) t - \frac{MA \cos}{2} (\omega + p) t. \quad \text{................. equ. 2,}$$

which has three components, the

carrier, on upper side frequency and a lower side frequency. Thus it can be seen that modulation is a process of generating side frequencies.

If we next consider power relationships it can be shown that

$$P\ \text{mod.} = P\ \text{carrier}\left(1 + \frac{M^2}{2}\right) \quad \text{.............. equ. 3.}$$

so that if M = 1 the extra power is 50% of the original carrier power. (It should be noted that this is the mean power, the peak power being four times that of the unmodulated carrier.)

Let us now consider two modulating sine waves of equal amplitude a, but differing frequencies w_1t and w_2t, adding them we get:

$$a \sin \omega_1 t + a \sin \omega_2 t = 2a \sin, \left(\frac{\omega_1 + \omega_2}{2}\right) t \cos \left(\frac{\omega_1 - \omega_2}{2}\right) t \quad \text{.....equ. 4.}$$

The parameter of interest here is the amplitude 2a which has doubled. If this resulting waveform is applied directly to the modulator, over modulation would result, generating a complex waveform containing harmonics to the detriment of the power in the desired side frequencies. So if two or more sine waves are to be generated simultaneously in the modulator it is advisable to reduce the output of each generator in proportion to the number of channels in use, i.e. 2 channels 50%, 3 channels 33⅓%, 4 channels 25%, etc. so that the peak modulation factor never exceeds 100%.

This is not strictly true because it has been shown[3] that when n sine waves are combined together and are not phase coherent, the probability of them all reaching their maximum amplitude at the same instant is small, it is thus possible to increase the outputs of each channel slightly above the figures quoted, which is advantageous.

However, no matter how perfect the transmitter, serve distortion can be too easily introduced in the receiver.

Demodulation (Detection)

It is the writer's opinion that the best form of receiver to use is the superhet with A.G.C. (automatic gain control). Such a receiver invariably incorporates a diode detector which gives linear demodulation. (It must be noted that without A.G.C. the superhet would be useless for multi-channel operation since at close ranges the modulation intelligence could well disappear by limiting.)

However, superhet receivers are still rare in the modelling field and for reasons of economy the single valve or transistor super-regenerative detector is used.

This form of receiver has been fully treated by J. R. Whitehead in his book[4], and it is shown that the self-quenched super-regenerative detector operates in the Logarithmic Mode.

There emerge several important points of note:

(a) When the received signal is amplitude modulated the output term carrying the modulation frequency is independent of the carrier level at all signal levels well above circuit noise, thus perfect A.G.C. action is inherent in the operation of the receiver—a good point.

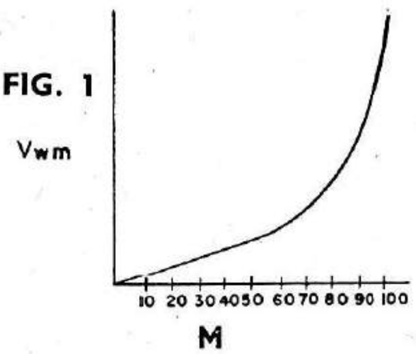
(b) There is considerable distortion of the modulation envelope. Both Strafford[5] and Whitehead have proved that the output of the modulation frequency

$$V\ \omega m\ \alpha\ \left(\frac{1}{M} - \sqrt{\left(\frac{1}{M^2} - 1\right)}\right) \cos \omega\ m.t.$$

However, the relationship between output and modulation depth is not as bad as it first appears because if V wm is plotted against M. fig. 1, we see that a fair degree of linearity exists up to M = .6 (i.e. 60% modulation).

At 80% modulation, intelligibility starts to break up and the depth should not be exceeded.

FIG. 1



(No doubt many readers will now be complaining that as their reed receivers do not work unless 100% modulation is used for one channel there is little chance of operating two or more channels at once. The answer to that question can be seen by looking again at Fig. 1 and the solution lies in increasing the audio gain after the detector.)

(c) The optimum quench frequency for 27 mc/s operation lies between 30-40 Kcs., so it is necessary to bear in mind the fundamental limitations imposed upon the upper value of the modulating frequency by the interruption or sampling at quench frequency of the output. Although information theory tells us that only two bits per cycle are required to reproduce a sine wave it is recommended that the highest frequency used shall not exceed 10 Kcs. This, of course, does not affect the tuned reed system which usually operate in the region of 200-600 c/s, but it is of interest to would-be users of tuned filters.

Those amongst us who feel by now that the problems are insuperable may take heart from the knowledge that the next article will be more practical, correct and incorrect methods will be described and proved circuits given.

References :

1. Handbook of Line Communication. H.M.S.O.
2. F. E. Terman. Radio Engineering.
3. M. Slack. The Probability Distribution of Sinusoidal Oscillation combined in random phase. J.I.E.E. Pt. III. 1946.
4. J. R. Whitehead. Super-regenerative Receivers
5. F. R. W. Strafford. Journal I.E.E. Pt. III. 1946.

INTRODUCTION TO TRANSISTORS (Continued from facing page)

to cause operation of the relay under no signal conditions, i.e. with Tx. off.

The first two audio stages are transformer coupled and their design was described in Part 4. The capacitors across the primaries of the audio transformers are used to filter out the quench frequency by reducing the audio gain at frequencies above the tone range. Their values can be increased if, when the Rx. is tuned in to an unmodulated Tx., the relay current does not fall to 1 m.A. or less.

The output stage which controls the relay current operates under 'Class B' conditions. Unlike the previous audio stages which pass current throughout the audio cycle this stage has no forward bias and only passes current during the negative half cycles of the audio tone (see Fig. 1).

The fact that the collector current waveform is distorted is not particularly important for reed operation (unless simultaneous operation is required) and a reed unit with a D.C. resistance of about 100-150 Ω will be satisfactory. The electrolytic from collector to emitter should be replaced by a 0.01 μF. capacitor when a reed unit is connected in place of the relay. For relay operation, as shown, the electrolytic is required to sustain the voltage across the relay between collector current pulses. Without it relay current would also flow in pulses (limited by the relay resistance to about 20 m.A. peak with a 200 Ω relay), and the average value would be low.

The pulses of collector current discharge this capacitor and its charging current 'fills in'. With a relay of 200 Ω resistance the average current during operation will be about 20 m.A., which means that the output transistor will need to pass peak currents up to 150 m.A. whilst discharging the capacitor during the pulses, and this is why a 'switching' transistor like the OC 76 is recommended for this position.

The operation of the Rx. can be checked stage by stage using high resistance 'phones (2,000 Ω or more) one side to the +ve battery terminal and the other via 0.01 to the base and collector of each audio stage in turn.

Start with ten turns 28 g. enamelled on the tuning coil and if the core sticks out too far when tuned, take one off. R.F.C. is as for Fig. 5 page 254.

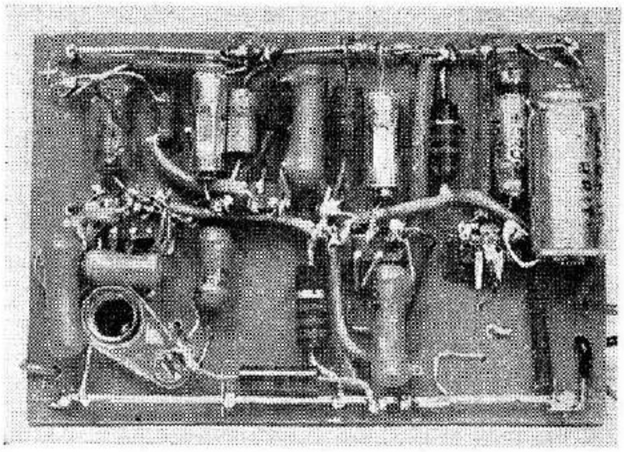
The audio transformers are Ardente T 1079's, these should be handled with care. I find it advisable to strengthen the cheeks with a liberal coating of Araldite which prevents the lead out wires from twisting and breaking the internal connection to the fine winding wires (see photo).

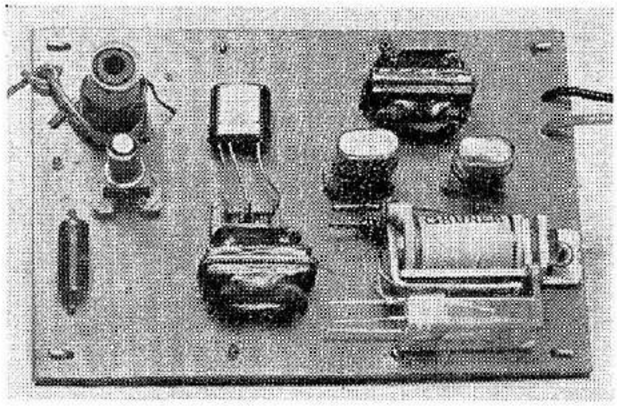
ARE YOU LICENCED?

Just in case newcomers to Radio Control are not aware of it — you need a licence for operating remote control equipment. No tests, just fill in a form and pay £1 for five years cover. Application form and full particulars from Radio Branch, Radio & Accommodation Dept., G.P.O. Headquarters, London, E.C.1.

Introduction to TRANSISTORS

In Part 5 Dave McQue provides a practical example of what has gone before in the shape of an interesting all-transistor receiver.





THIS little all transistor single channel tone or reed Rx. is offered as an example based on the circuits explained in previous parts of the series.

The first stage, the superegen, detector (see Part 3) uses an SB.305 which, at fifteen shillings from Messrs. Henry's Radio, makes an economical as well as efficient choice. The component values are not the same as those of Fig. 5 of the September article due to the differing biasing conditions, this is so that a tapped battery can be used for biasing which will save the weight and cost of the potential divider chain in a really tiny version. The current consumption of the set is so small that a switch is superfluous, switching on being performed by plugging into the battery which can be three slim pencells.

The output from the superegen. stage is taken from the emitter by direct coupling to the first audio stage, this saves the need for any coupling capacitors and provides D.C. stabilisation for the audio stage. The value of the coupling resistor given is nominal and can be increased if the gain of the succeeding audio stages is so great as

(See facing page)

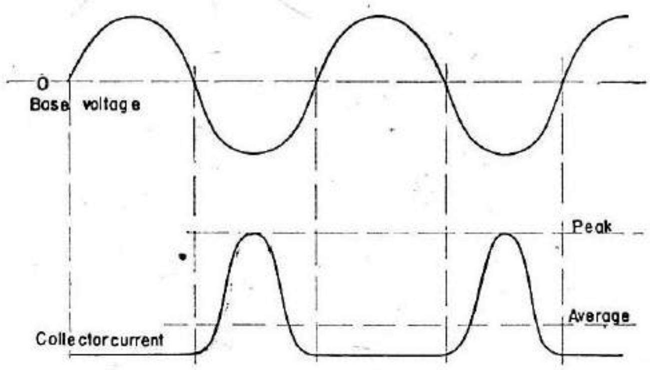
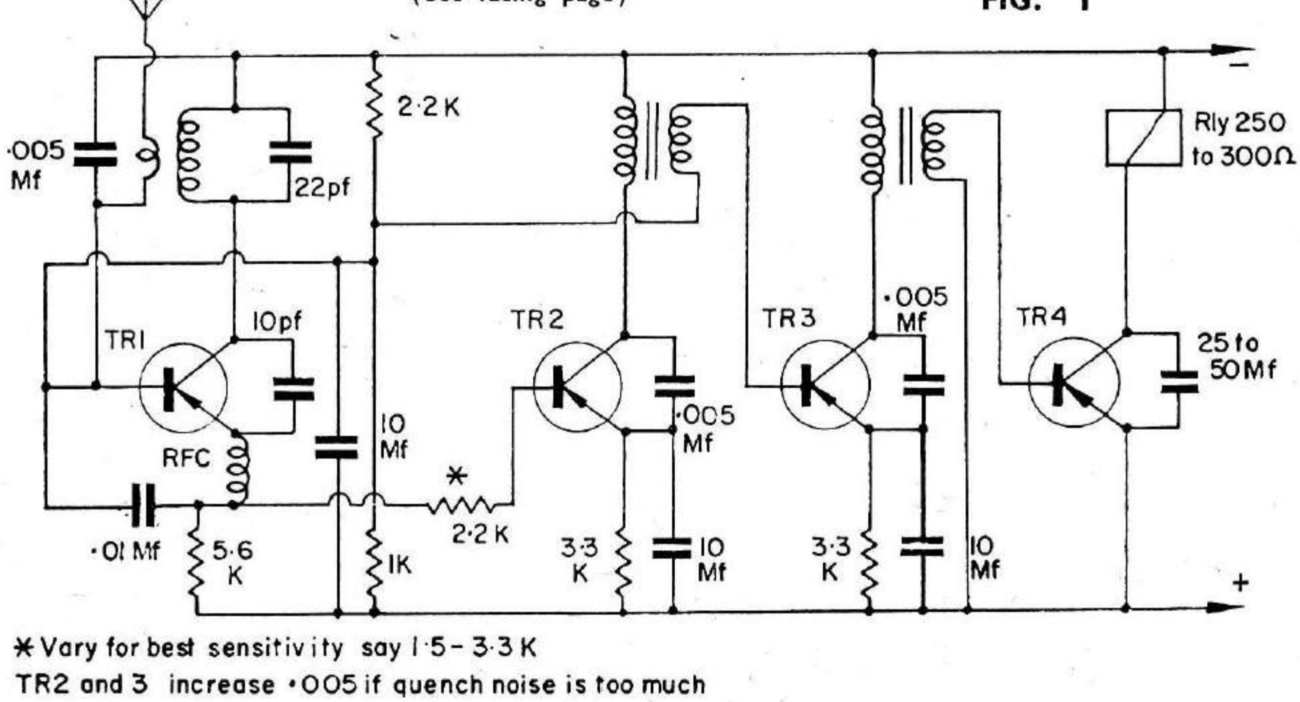


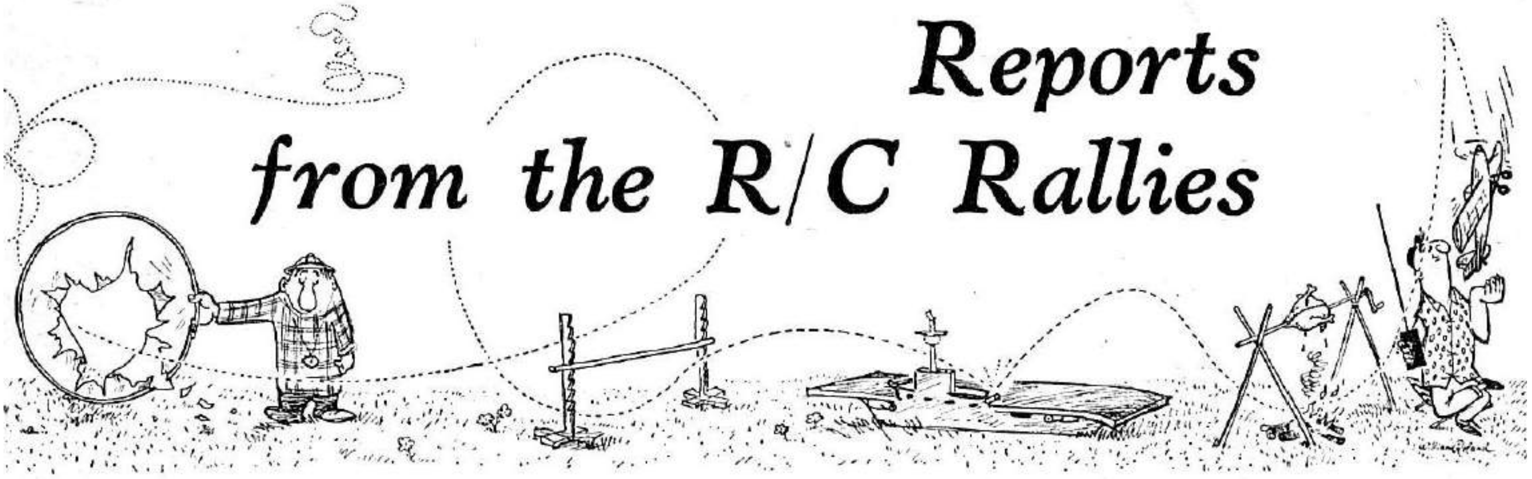
FIG. 1



✱ Vary for best sensitivity say 1·5 – 3·3 K

TR2 and 3 increase ·005 if quench noise is too much

Reports from the R/C Rallies



The I.R.C.M.S. Annual Contest for Aircraft

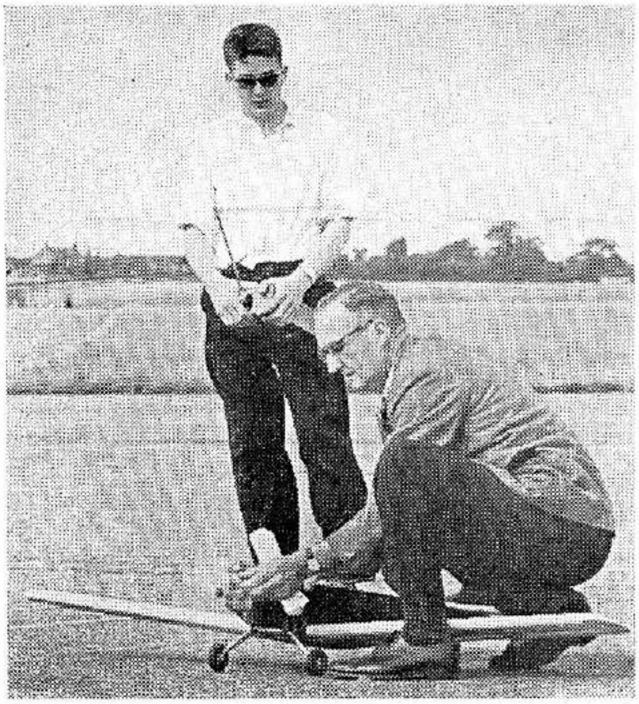
THIS was held on August 21st at Wellesbourne again, and attracted a record entry. The list was closed with 60 entries a fortnight before the final date.

To start the proceedings Ed. Johnson made a flight for the T.V. cameras, with a low wing model of John Singleton's design. It was much like a very simplified 'Orion', and called *Skylark*. The radio was Stegmaier, with a pulser on the elevator.

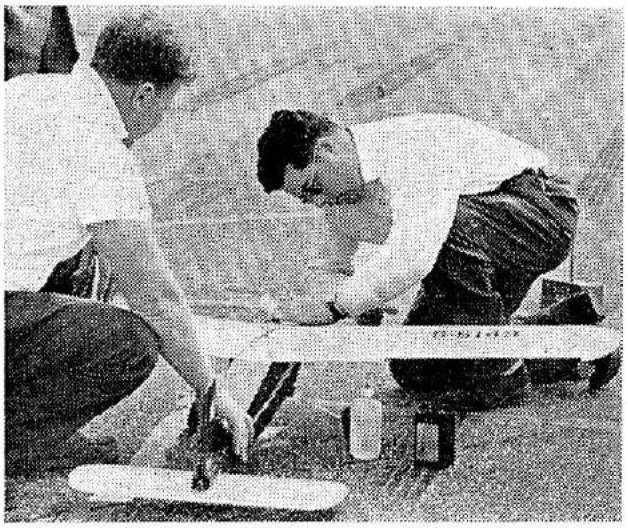
The Multi-control section was won by Paul Rogers of High Wycombe with a Fox powered model using *'Orion'* wings and tail, and simplified fuselage, with R.E.P. Octone radio, scoring 355 points. Second man was John Singleton with his *Skylark*, using Omu transmitter and receiver with the relays operated from the actuator batteries, and Bonner servos scoring 280.3 points. Third was P. T. Waters of Port Talbot, scoring 280 points with a K and B 45 powered *'Orion'* and Octone radio with Bonner Duramite servos. Next came M. Franklin of Leicester at 192 points with a *Crusader*, and Ed. Johnson with 162 points. The contest allows 20 points for a special effect, and Ed. had a "gimmick" for this in the form of a streamer released by the first application of 'down elevator'. Unfortunately it jammed, and Ed. was unable to obtain 'down elevator'. There was speculative anticipation when Mr. Griffiths of Wales said he would drop an egg. He did too, splat on the runway within splash distance of a group of spectators!

The "Gadget" class was a poor show. In this, any quantity and variety of controls can be used, providing they are obtained with carrier only, or a single tone. B. Wood was the only one to make a reasonable flight, and used engine and rudder. The engine was frequently slowed to avoid climbing too high.

The single control class was notable for the number of *Gassers* and Wright radio. One such combination in the hands of J. Pearson won with 161.3 points. Second was S. J. Wood of North London with 151.6 points with a model of his own design and home made radio. Third was A. H. Fallon with a "Gasser" and home made radio, using crystal control on the transmitter. Fourth was B. J. Wood with 126.6 points and equipment similar to his father's, S. J. Wood.



That most successful father and son combination, Paul Rogers with Rogers, Senr. and their modified "Orion", R.E.P. Octone equipped. "Near miss" for national team honours young Paul can now claim in boxing parlance to have "beaten the best".

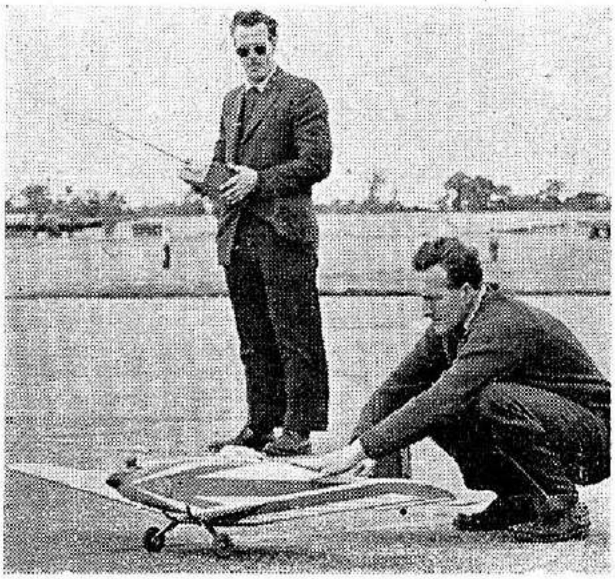


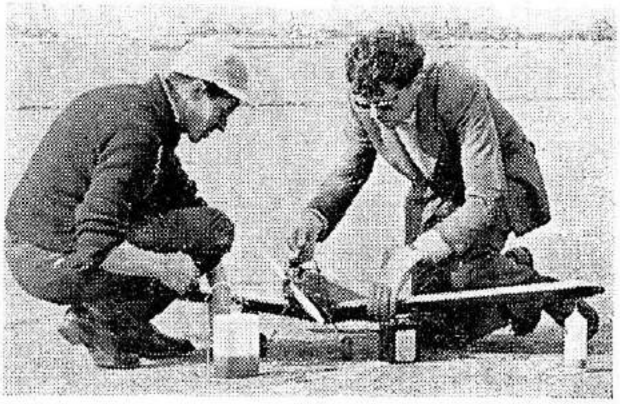
Stewart Uwins assisted by Angus Macdonald makes ready his "Zurich" model—which incidentally did not suffer from relay trouble there but that crazy fault a broken wire !

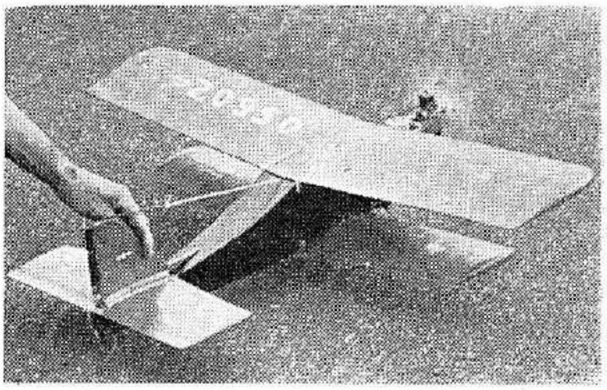
The weather was good throughout the day, but the wind was a bit too strong for good single control flying. A number of shops turned up. Veron had models only on show, model aerodrome, and Roland Scott had kits, radio and engines, and Howbell Models had various accessories and a workshop for the use of any modeller on the field. The table of prizes looked like another model shop with all the engines and accessories.

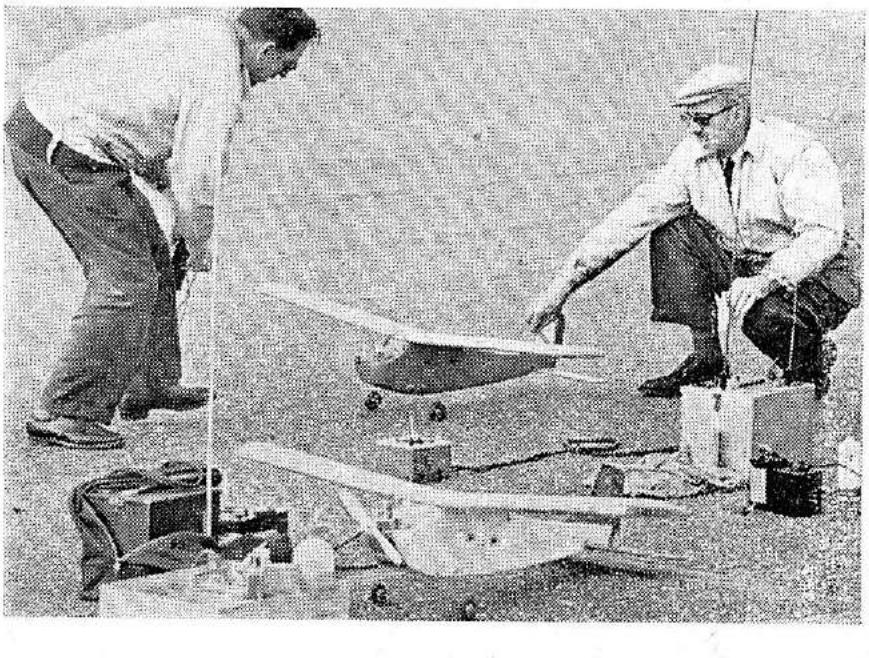
During the lunch break, before the full crowd had arrived, the writer counted 180 cars from standing on the saddle of a stationary motorcycle, but only a very small amount of litter was left.

The number of competitors to actually make an attempt was 49, starting at 11 a.m. and finishing at 7 p.m.









M. Franklin with his de Bolt "Crusader", R.E.P. Rx. and Merco powered, that popular British combination.

Ed. Johnson, who has not been enjoying the best of fortune, assisted by John Singleton.

G. Hales' interesting biplane, Wright radio equipped, seen at both I.R.C.M.S. meeting and South Midland rally.

Charles Riall in characteristic pose assists E. Faulkner, A.R.C.C.

Radio Control Contest, South Midland Area

SINGLE control was run first and most of the entrants had taken part in the previous week's event at Wellesbourne. Their flying did, however, seem to be a little better standard, the wind being less strong, though still too strong for good flying. Messrs. B. Wood and G. Marsh were better this time, and tied for first place with 46.5 points. Mr. J. Pearson, the previous week's winner came third with 42 points. Mr. S. J. Wood was fourth with 38.5 points, still showing parental superiority over his son, B. J. Wood, who was seventh with 34 points. In between were Mr. Crabtree 37.5 and Mr. Thornton 35.5 points. Twenty competitors made attempts.

Chris Olsen started the multi control, and although the engine cut before he had finished the schedule, scored 1,458.5 points which won him the contest. Paul Rogers made the second flight scoring 1,427 points to reach second place. Ed. Johnson was third with a new model Skylark on its second flight, using Orbit 10 radio, at a score of 1,047 points. Fourth was Stewart Uwins with 964 points. He was unfortunate enough to lose down elevator while flying low inverted, after taking off with no rudder anyway. Mr. Brown flew an Uproar to fifth place at 837 points and Mr. Riall was sixth at 745 points with his Galloping Ghost.

The Pylon race was won by Chris Olsen, just half a second faster than Mr. Waters Orion. HOWARD BOYS.

Southern Counties Radio Control Rally

THE competition was held in almost ideal conditions, very little wind and bright sunshine for most of the day. Competition started at 10.30 with single channel, outstanding flight was that of M. B. Fellows with a score of 860.3.

The single event was followed by intermediate who attempted the new multi-schedule, the eventual winner E. Falkner also placed sixth in multi.

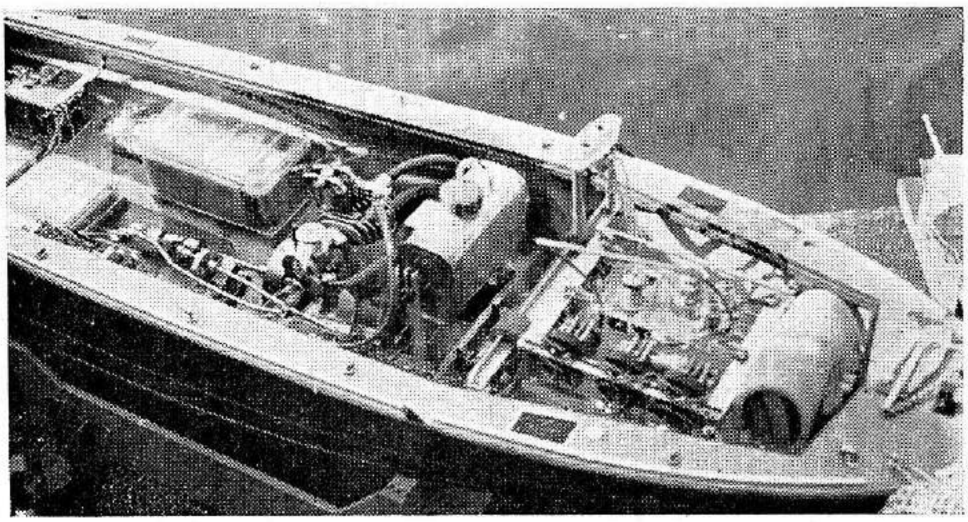
The multi event starting at 2.30 was interrupted at 3.30 for half hour demonstrations of acrobatics by the Army Air Corps, whose main training centre is Middle Wallop.

The multi competition finished at about 5 o'clock, best flights being by Ed. Johnson and Paul Rodgers. An amusing note was struck by Owen Griffiths whose Smog Hog dropped a fresh egg with a streamer attached. The idea being to hit the spot marking the spot landing, but he came nearer to hitting the judges, unfortunately down elevator stuck on later in the flight and the model crashed into the car park.

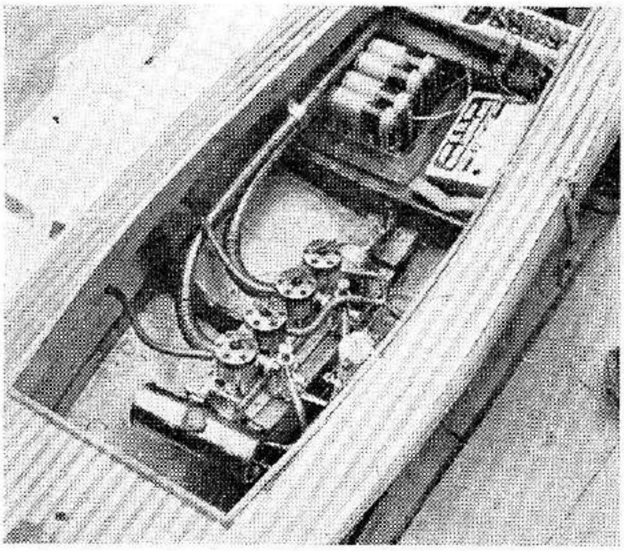
Attendance at the rally was very good, there being about 250 cars present each carrying three or four people on average. One good point was the behaviour of the crowd when asked over the P.A. not to leave litter, when they had gone home there were only three pieces of paper to be seen left on the grass. Good show, thank you.

The prize-giving was held at 6 o'clock the prizes being given away by the Station Commander's wife. Competitions in multi and single received prizes down to sixth place, and in intermediate down to third. With the multi and intermediate class winners receiving a cup and trophy respectively to be held for one year.

All things considered a good time was had by all.

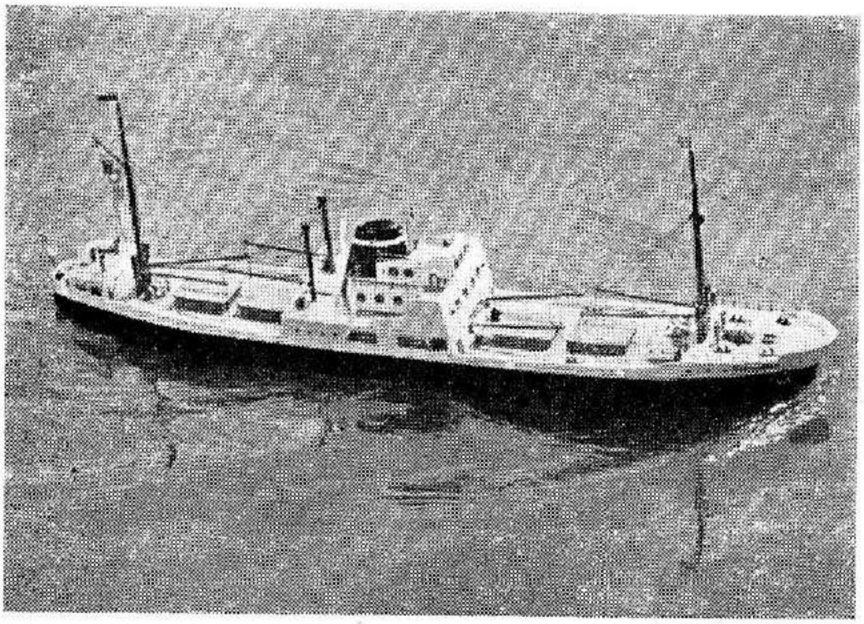


Left, Winner of the Prototype Cup at the M.P.B.A. Grand Regatta was this fine Thornycroft Range Safety Launch built by J. Stevens of Bromley. Radio (only an incidental in this competition) appears to be 3-channel, presumably giving optional rudder and sequential engine speed.

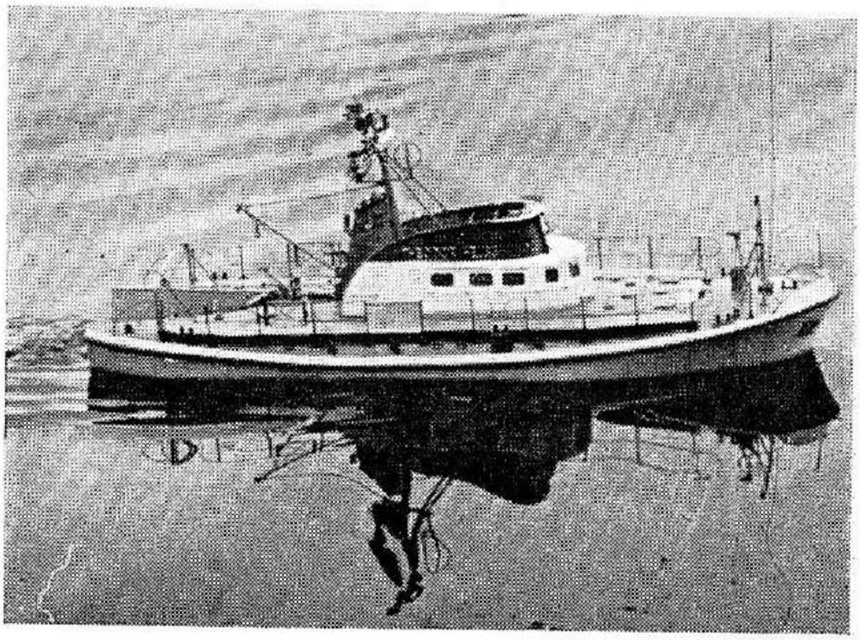


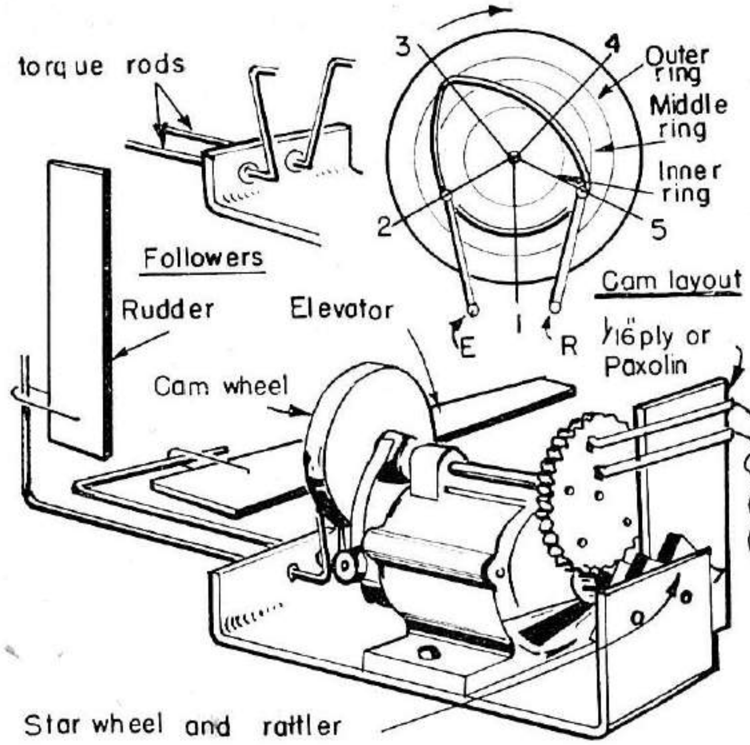
ULM MEETING

ONCE again a splendid entry, especially in radio, was attracted to the annual regatta at Ulm/Donau, South Germany. The Union Jack was waved in no uncertain terms by Col. Taplin and John Taplin — 1st and 2nd respectively in R/C steering (60 entries), 1st balloon bursting (J.T.), 2nd in speed (H.J.T.) and a sail-over 1st in R/C yachts. Above is the four cylinder speed entry, which at 22 secs. was four secs. ahead of Kleinespel's G a n n e t powered model, next fastest. P. J. Tinlin (U.S. Forces) tied with a Fox .59 model; then came Willi Neurohr of Worms, also with a Fox 59, to cover the 100 metre course in a scorching 14.4 seconds! That's Willi's wife holding *Metro* (Metz R/C gear) top right. The freighter (left) by Helmut Zeiler, Tubingen, has 18 radio functions, including loading cargo, etc.—hatches and derricks are worked by the radio! Bottom is Gleichfalls van Happach's air/sea rescue launch *Theodor Heuss* minus the daughter boat carried in the stern well. Hull is balsa, superstructure all metal.



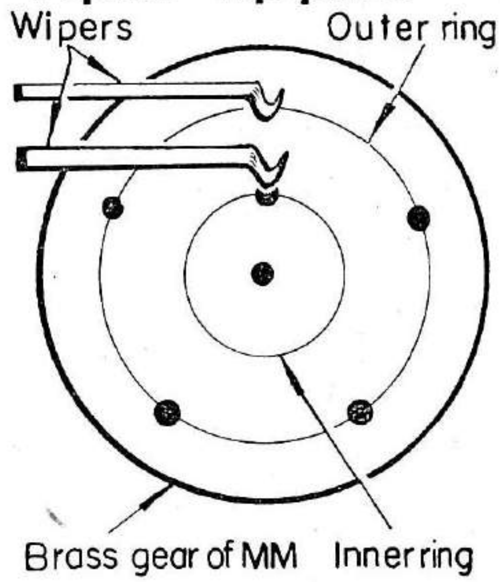
—(*Photos Schmolinske.*)





You Tell Us

Readers' Variations on Popular Equipment



Comp. Variation

THIS little actuator by L. E. Bowker from S. Rhodesia costs under £1 to make and is based on fellow-Rhodesian Gordon's M.M. compound and the Cobb Micro described in a recent *R.C.M. & E.*

Gordon's basic layout was used with following mods.: (1) Star wheel was soldered onto centre-shaft of the M.M. (2) "Rattler" was made of $\frac{1}{8}$ in. perspex bushed with $\frac{1}{16}$ in. i.d. brass tubing. (3) Wipers were rivetted on $\frac{1}{16}$ in. ply; contacts in a vertical line with C.L. of motor. (4) Brass wheel of M.M. was divided into five sections by drilling $\frac{1}{8}$ in. holes not quite through and filled with plastic wood, sanded smooth when dry and hard, four being on outer ring and one on inner (back contact of relay and neutral) (see sketch). (5) Pulley and shaft was replaced by a longer shaft of 16 s.w.g. piano wire, fitted with $1\frac{3}{8}$ in. dia. ex-clock gear. Cam track or groove of $\frac{1}{8}$ in. perspex is mounted on this.

Cam groove is made as follows: A circle equal to diameter of gear wheel is drawn and divided into five sections. Three concentric rings are drawn $\frac{1}{8}$ in. inside outer ring. These are numbered clockwise, one to five, starting from bottom centre. Rudder and elevator torque rod followers ride in positions 2 and 5, with fulcrums tangential. (see sketch).

By rotating the cam clockwise, the rudder arm will move first left then right; while the elevator moves right (up) and left (down). The inner cam section is cut first and mounted; then the outer ring is cut and filed until the groove just takes a 16 s.w.g. torque rod. Attach outer ring, clean up and run a soft pencil round and round to graphite groove for smooth action.

Torque rods can be of 16 s.w.g. wire with balsa extensions, and similar wires at their ends. Soldered washers or similar keep them in their grooves.

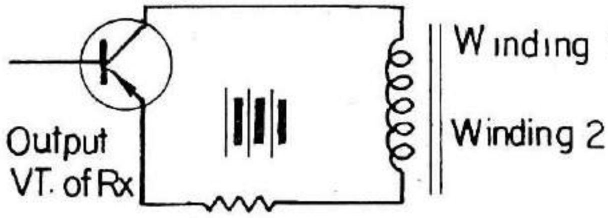
About $4\frac{1}{2}$ v. seems the best compromise between sufficient power for "gasser" types, and too fast for pulsing.

Whilst by no means original, this little gimmick does show what can be done simply by those too far from the 'shop round the corner' to rely on ready-made equipment.

Transistor Economies

By T. J. Froggatt

I cannot see any need to use two sets of transistors, namely VT 4, 5 & 6, VT 7 & 8, on the Nievergelt S.C. all transis-

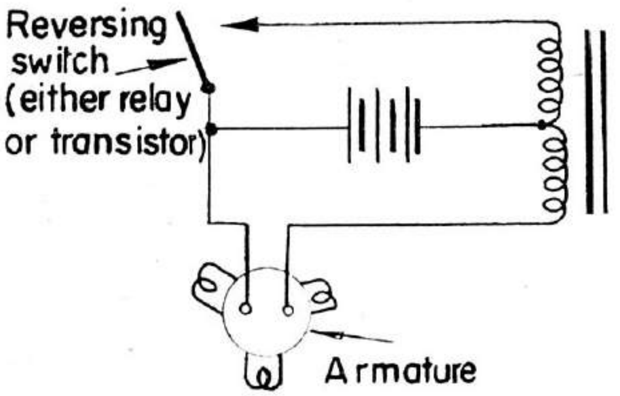


tor Rx., when surely one set would
The resistance is of such a value as
suffice using the circuit below.
to make the magnetism of winding 1

twice that of winding 2 when the output transistor is conducting.

The effect of this is that when the transistor is *not* conducting winding 2 gives a polarity to the winding as a whole, and when the transistor *is* conducting winding 1 'overpowers' winding 2 giving the reverse polarity to the winding as a whole.

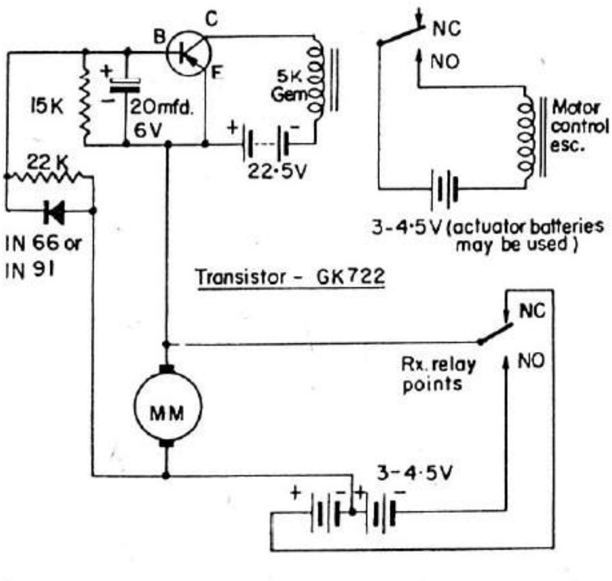
However, it *does* work for servos, if they have a field winding with a centre tap, as I have converted an old model railway engine to use it for a proportional system. To save current the armature becomes the resistance, thus:



Pulse Motor Control

(From FLYAWAY—Newsletter of Crescent City R.C.C., New Orleans

The circuit reproduced below is an infallible (?) motor control system for use with pulse systems. As can be seen, the parts are small in number and the whole works, including relay will fit in a very small box. which may either be attached to the Rx. itself or mounted separately. We use this to operate a Jap OS 4 claw escapement modified to 3 position job. If desired, the back contacts of the motor control relay can be wired into the actuator common lead for fail-safe function, ala TTWP. Wired in this manner, when the motor control relay kicks in, the current to the acuattor is cut off, and a rubber band centring device allows the rudder to come to neutral, or near neutral. Resumption of pulsing then puts current back into the actuator. As set up the motor control relay pulls in on a solid signal with a time delay of about ½ second. The addition of a small 0-25K. variable resistor in place of the 15K resistor will allow one to vary this interval as desired. If you need a good pulse system motor control (or auxiliary control) this is it—never misses—well, almost never.



"Boystick" Variation from N.Z.

By R. D. Whitehead

I have made the "Boystick" control box, using a single lever as illustrated below, and it has worked out very neat and light. I used Standard Telephones T55 transistors, a small 2200 Ω American relay, and 16½ volts. The pots. used are Rate 50K., mark space, 15K.

Here's the easily made pot. linkage.

I have found this works very well, and with rubber band centring has a good 'feel'.

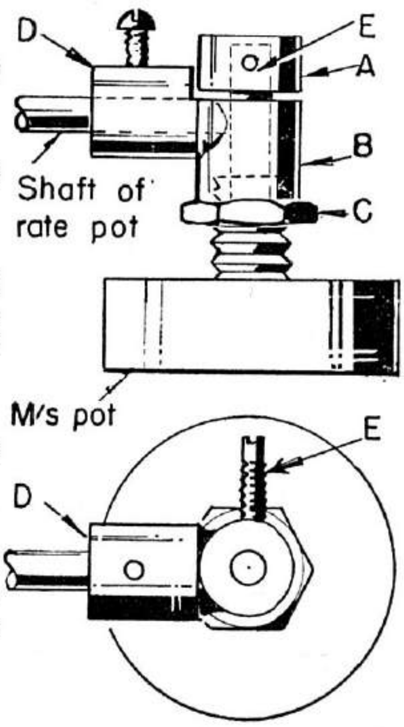
A, B & C Brass pot. connectors.

C Brass pot. nut soldered to B.

B Drilled out ⅜ in. near C to allow pot. thread to slide into it.

B & D Soldered together.

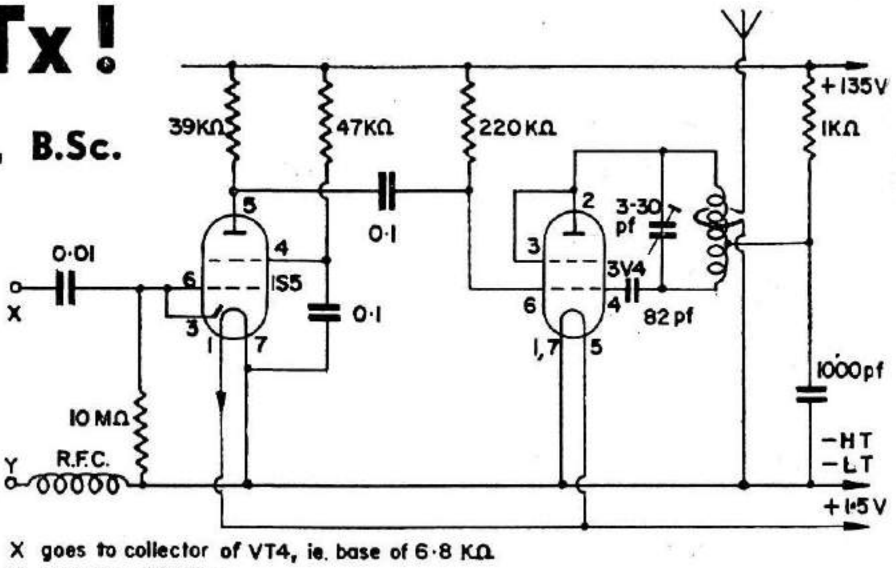
E Screws into A; locks on pot. shaft to form stick.



Let us have details of any interesting modifications you have tried that work.

Uni-Que Tx!

By Peter Lovegrove, B.Sc.



X goes to collector of VT4, ie. base of 6·8 KΩ
Y goes to − 9V line

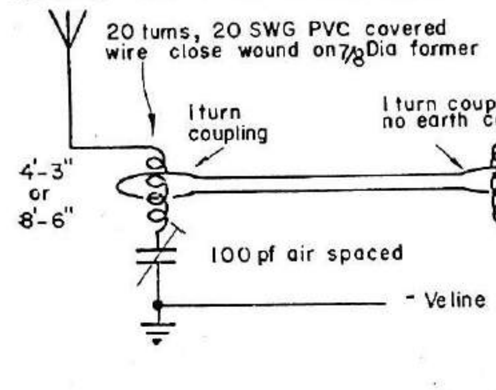
THE McQue Versatile Transmitter has tremendous advantages, that is undeniable, but to the not-so-experienced constructor it is rather a complex unit to build. In view of the relative simplicity of the transistor feed units it is a pity that people might be discouraged from using them because they are afraid to tackle the transmitter itself. The ad hoc arrangement described in this article might give L.H-R. and David McQue cold shivers but whether or not it is good electronic practice, it works and works well. The prototype has been in use for about ten months now without fault or criticism.

What has been done is to feed the 3V4 R.F. stage of a 'Unitone' transmitter with the modulation output from the 1S5 stage from the McQue "Versatile" which, in turn, will be driven by transistor units as described in the second issue of this magazine.

Valves

I understand that these valves should really be limited to 90 volts H.T. maximum, but my own experience and that of others is that they will function without trouble on 135 volts. One would expect the increased H.T. to reduce their life, but with the modest use that transmitters get as compared with domestic radios the reduction should not be noticeable.

In any event, 135 volts H.T. is specified because the prototype was a portable transmitter fitted with a neck-strap, for convenience in flying, Simpl Simul. A 4 ft. 3 in. aerial with end-loading was used. If a ground-based Tx. is required, with an 8 ft. 6 in. aerial 90 v. is quite adequate, particularly if aerial loading is used. Fig. 2 shows how a Judd tuning circuit may be fitted to either length of aerial.



Range

I refuse to quote any specific range figures since they would only apply to a given transmitter—aerial and receiver—battery arrangement. Even dryness of the ground affects the issue, so suffice it to say that with any reasonable tone set, say an Aerotone, Unitone or Quetone, you should get at least 500 yds. ground range unless your batteries are dying a slow death.

Circuit Details

The tuning coil is made from 14 gauge copper wire, tinned or enamelled. It has 10 turns about ¾ in. inside diameter (wind on a ⅝ in. former, e.g. an old battery) and is tapped four turns from the grid end. Stretch to about 1¼ in. to 1½ in. length. Tuning is done by the 3-30 pf. beehive capacitor across it. The aerial coupling is one turn loosely wound round the tuning coil as in the Ivy A.M. Transmitter with one end earthed and the other connected to the aerial. The aerial may be centre-loaded as in the Ivy A.M. or end loaded as in Fig. 2.

On the circuit diagram one R.F.C. is shown in the earthing input lead, but it may be found that a second one is required between the right-hand end of the 0.01 mfd. capacitor and the top of the 10 M Ω resistor (junction with valve tags 3 and 6). The indication that this is necessary is that the pulse rate put out by the control box is speeded up tremendously when the box is coupled to the Tx. Listen to the control box output directly, by headphones, or by feeding it straight to the pick-up sockets of your domestic receiver, and then compare with the pulse rate as heard from a model receiver by normal transmission. Feed the P.V. sockets from either end of your relay coil. If the two rates are not the same, fit the second R.F.C.

Do not put in two R.F.C.'s at first; the second one proved detrimental in one transmitter. 38 s.w.g. enamelled wire wound close on a 1 in. × ¼ in. dia. former is adequate for each R.F.C.

Depth of modulation is usefully improved if the R-H end of the 0.1 mfd. capacitor between pin 6 (3V4) and pin 5 (1S5) is isolated and a resistor of 22-47 K Ω inserted between it and the junction of pin 6 (3V4) and the 220 K Ω resistor. If you have no indication of mod. depth then put in a 22 K Ω at the start.

With reasonable modulation depth the output recorded on a field strength meter should drop at least 20% when modulation is switched on.

H.T. consumption is about 7 m.A. on 90 v. and 12 m.A. on 135 v. For setting up the aerial tuning, you need a field strength meter for best results. Start with the top of the 100 pf. capacitor disconnected from the 20 turn coil. Put on a short wandering lead and solder the stray end to a pin. Push this into one turn of the coil about five turns down from the aerial end. (Have the aerial in place, of course.) Vary the 100 pf. over its whole range and note the peak reading on the F.S.M. Now move the pin down and turn and repeat. Solder the capacitor connection to the coil turn, which allows you to tune to the highest reading on the F.S.M.

Elevator and Proportional Rudder

(*October issue, page* 303)

Continued experiments with this system have shown the need for slight aerodynamic and static balancing of the elevator. Do not overdo aerodynamic balancing on any model; it tends to lock the control surface up or down at speed. 20% is a safe maximum, less is better.

Three volts each way or 2.4 volts from Deacs is better than 1½ volts on the "Tornado".

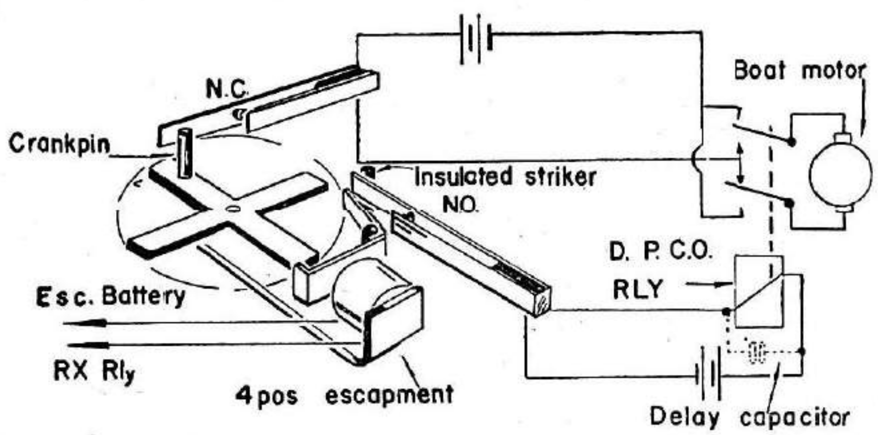
Use a pulse rate of about 10-15 c/s. It will appear that the Gasser rudder is inadequately moved with 50% mark-space variation, but I will guarantee your first turns will be overdone, to the extent of piling in, probably.

Watch the brushes on "Tornados"; they have a habit of developing wide dead-spots. Doctoring will refresh them.

Arrange the wire work so that when the elevator is in one of its operated positions the striker loop makes a right angle with the actuating lever on the front of the elevator shaft, looking along the shaft. This ensures that the elevator really locks and cannot be blown back to neutral.

More Work from the Escapement

By A. BUDEAUX



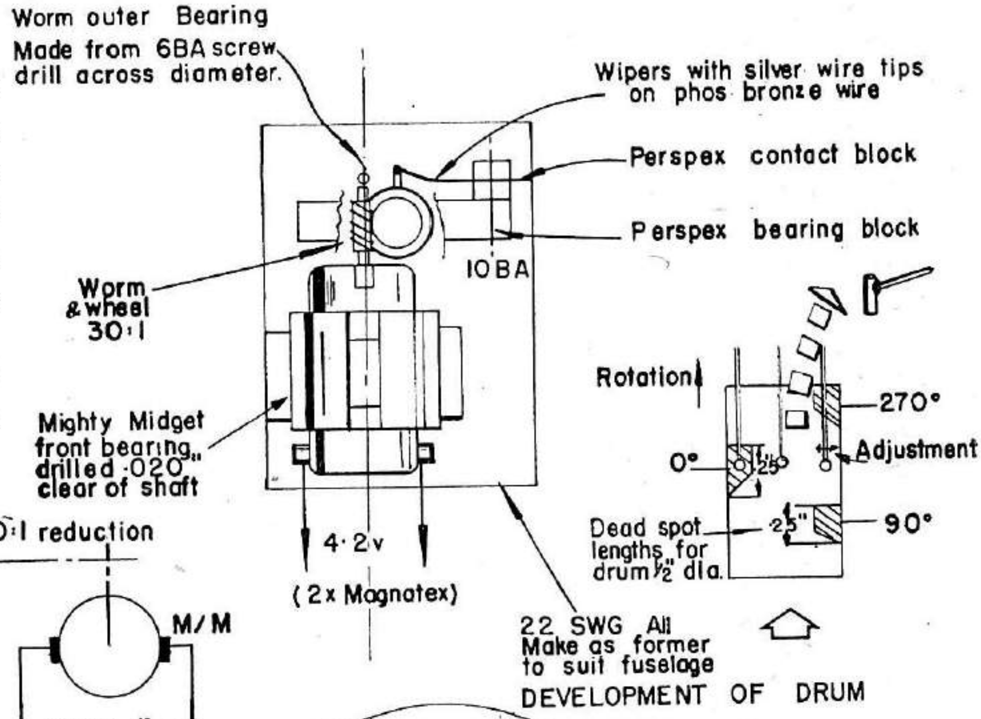
THREE systems of control for model power boats have been developed by the author. The first, after studying the article on simple boat control in the pages of this journal, was a simplified version of the escapement operated switch.

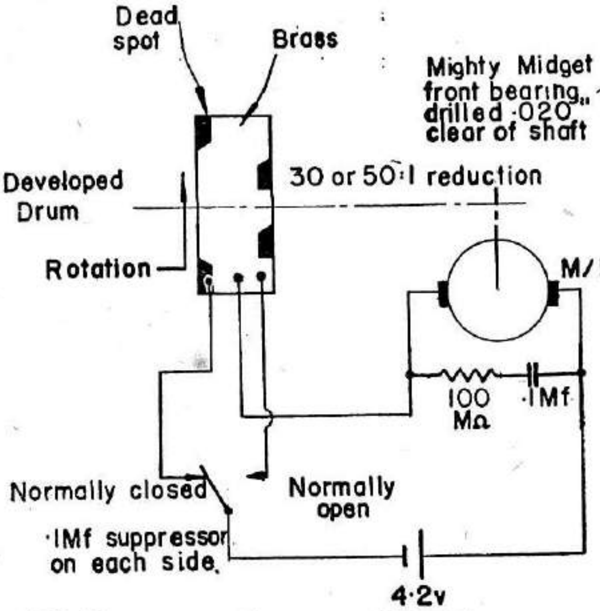
The model is electric powered and carries an E.D. 4 position clockwork escapement to operate the rudder.

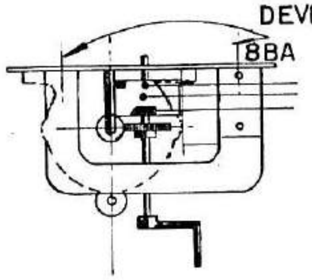
Modification number one was to fit a pair of normally closed contacts close to the star wheel so that on one neutral position the boat motor circuit was broken, giving the following sequence:

(Continued on page 362)

A very simple single channel actuator developed on the same lines as the more elaborate boat actuator by I. R. Bittle in our last issue, once again by that North Kent Nomads stalwart Geoff C. Chapman.







Single Channel Actuator

THIS motor driven actuator is based upon Laurie Ellis' original idea (published *Aeromodeller,* Feb., 1957). The most important difference being the use of a 30 : 1 or 50 : 1 worm reduction, so that up to 4.5 v. may be used with a more than sufficient power output with snappy action.

The actuators in the writer's models (Sparkys) are operated by two Magnatex cells (elec. lighter batts.) to give 4.2 v. nominal, these last some six to eight weeks of evening and weekend flying. The writer is grateful to Eric Hook for pointing out that these cells can be recharged by inverting them and charging at 10-20 m.A. for 30-15 hrs. A rough guide that they are fully charged is when they swell up. Once taken off charge they quickly resume their normal proportions.

Construction

The Mighty Midget motor is taken apart, and if one has the means a small brass bush inserted at the commutator end—care must be taken that the bush does not short out the commutator segments.

The worm is drilled as concentrically as possible—the dia.; just a push fit on the armature shaft. A spot of solder ensures the coupling.

The Mighty Midget case is opened out to clear the worm and the M.M. reassembled.

The base plate is made to suit the model and the M.M. mounted to it. The gear centres can be estimated by holding in mesh and measuring with dividers—the object being to have them in reasonably slack mesh.

The contact drum is fashioned from a piece of ½ dia. brass tubing by fret-sawing and filing. The angular location of the dead spots being by no means critical. The brass sleeve is then pushed on to an ebonite rod previously mounted on the 16 s.w.g. mainshaft, the gaps filled with Araldite and wrapped with tissue to hold in place whilst curing (270% for 45 minutes). After curing the drum is cleaned over the periphery by file or in the lathe.

Whilst the drum is curing one can produce the outrigger bearing for the worm shaft. This is a 6 B.A. steel screw, filed 'D' section on its end and

AVAILABILITY

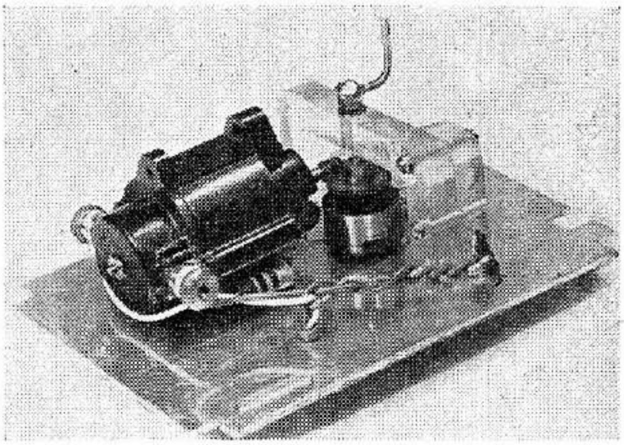
Worm and worm wheels — H. Franks, Oxford Street, W.1. 1/- for two pairs.
Magnatex cells — Lewis Tobacconists. 3/- each.
Brass, ali., etc. — Smiths, Clerkenwell. Screws, phos. bronze wire.
Silver wire 18 s.w.g. — Johnson Matley, Hatton Gardens. 2/8d. for about 6 ft.

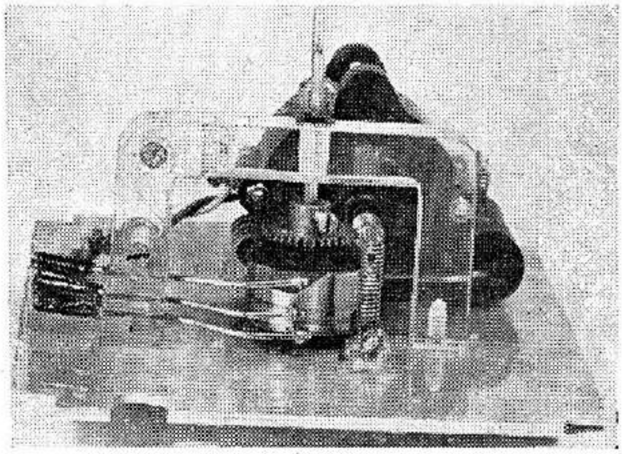
drilled to receive the spigot of the worm shaft. By drilling a clearance hole in the base plate and fitting nuts either side a means of height adjustment is achieved. At this point the motor is given a run and if 1.5 v., turns it over then all is free and alignment satisfactory.

The drum shaft is fitted with the worm wheel (the 50 tooth one is a good push fit on 16 s.w.g.) and the shaft assembled to the base plate.

The 'U' shaped contact and outrigged drum shaft bearing carrier is made from ¼ in. perspex — suitably bushed. The contacts are made as previously described from phos. bronze wire tipped with silver and mounted in a separated perspex block held to one leg of the 'U' shaped bearing carrier by 2-10 B.A. screws.

The actuator is wired up as shown and bench tested using a 4.5 v. 128 g. battery. The wipers are pre-sprung to give just sufficient bearing on the drum to pull it up on the dead spots. Further adjustment is achieved by moving the

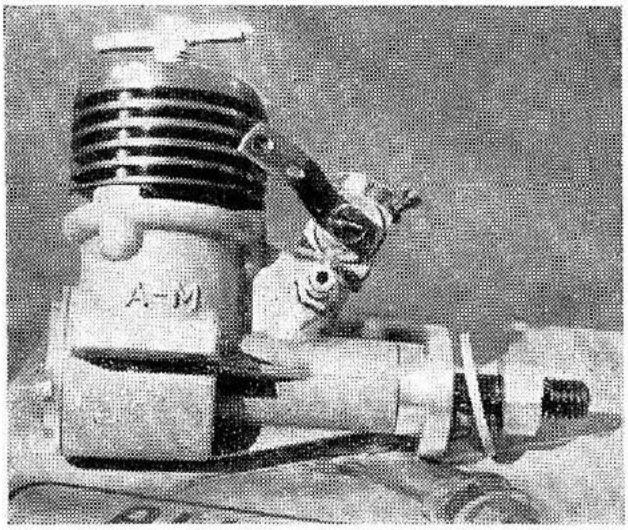




Two views of the actuator shown on baseplate that doubles as a fuselage former in the author's "Sparky".

outer wipers sideways, although this is best left for adjustment in the model as the actuator wears and/or vibration plays its part.

After some button practice one soon achieves the one for left two for right technique.



A.M. 15 available in R/C Guise!

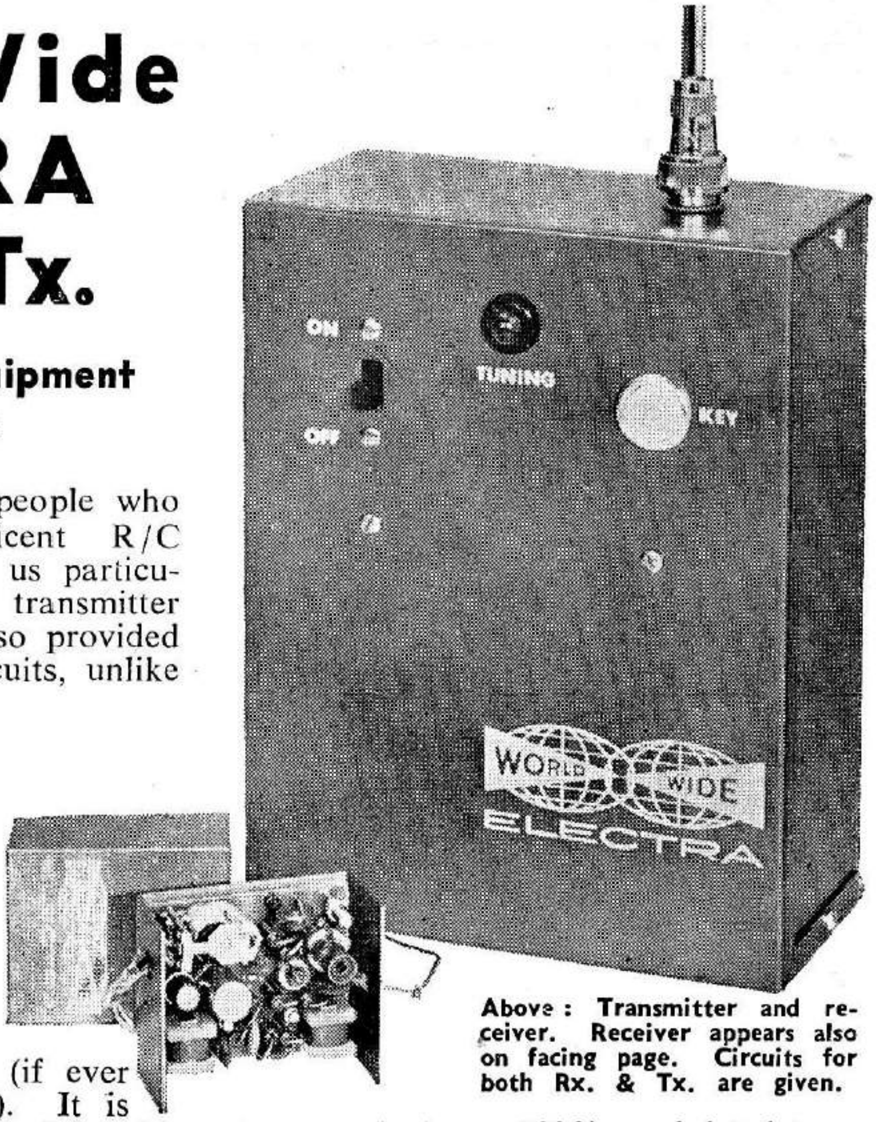
A.M.15 available in R/C Guise!

Picture taken at South Midland Rally gave us first clue that well tested A.M. engine model for R/C use was actually on market. Early prototype has been in *Aeromodeller's* Ron Moulton's possession for quite some time—but very much off the record. As will be noted it comprises, basically, a motor control attached to choke tube to enable speed to be varied. Range that can be controlled is from 12,000 r.p.m. down to 4,000 r.p.m. (just a low purr) though more adventurous people may extend this at their own risk. Price fitted to A.M.15 is 70/8d. complete, on the A.M.10 69/8d. No conversion service is envisaged, though units may be available at just over 10/- for anyone who wants to convert his own engine.

World Wide ELECTRA Rx. and Tx.

New low cost equipment from America

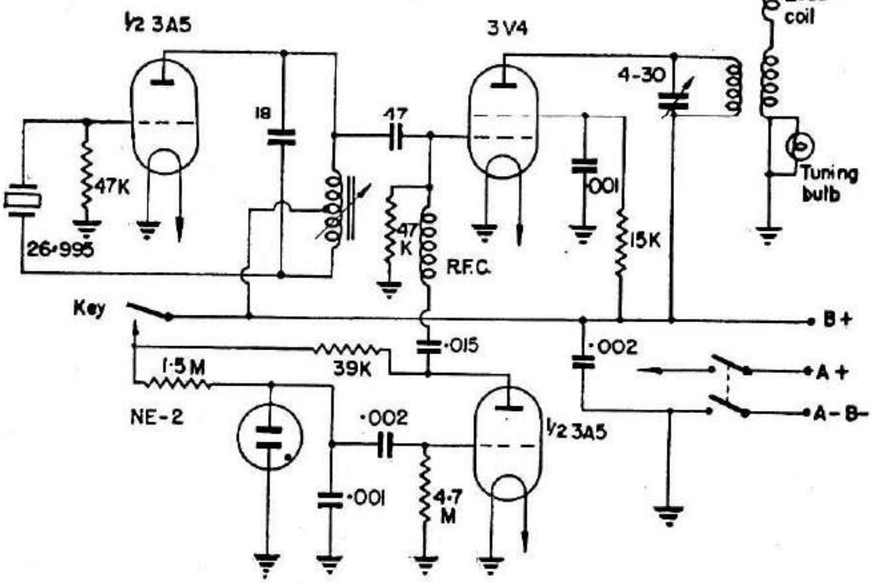
WORLD WIDE RADIO, the people who publish that magnificent R/C equipment guide, have sent us particulars of their new Electra transmitter and receiver. They have also provided us with the appropriate circuits, unlike one or two manufacturers who regrettably have not seen fit to release this information, although obviously the knowledgeable can easily deduce it from a quiet evening with a set.



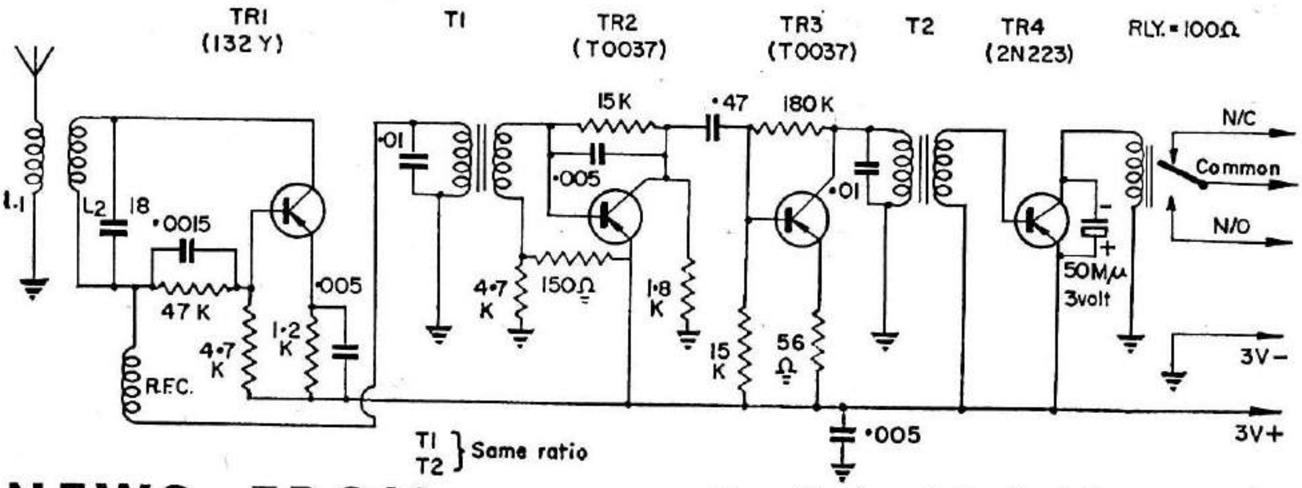
Above: Transmitter and receiver. Receiver appears also on facing page. Circuits for both Rx. & Tx. are given.

Receiver is a single channel super-regenerative tone unit featuring an all transistor circuit, stabilised for extreme temperature ranges (if ever we have a summer again!). It is claimed to be almost indestructible with its epoxy glass fibre board and heavy duty case. It is very fast pulsing, using a Deans subminiature relay. Operating voltage is 3 volts; idle current 3 to 4 m.A., 28 to 30 m.A. with signal. Supplied in red anodised case measuring $1\frac{3}{4}$ in. × $2\frac{1}{8}$ in. × 1 in., weight $2\frac{1}{4}$ ozs., factory tuned to 26.995 mc/s. American selling price is $24.95.

Transmitter is a high power MOPA type producing a 100% modulated tone of 800 c.p.s., and will operate not only its companion Rx. but also any other tone receiver on the market today. It is supplied with chrome plated extensible aerial with amphenol connector, and case again is red anodised to match Electra Rx. Size is 6 in. × $7\frac{1}{2}$ in. × $3\frac{1}{8}$ in., weighing with batteries $3\frac{1}{4}$ lbs. Battery requirements $1\frac{1}{2}$ v. and two $67\frac{1}{2}$ v. As will be noted from circuit it is crystal controlled. Price is $26.95.



These two units appear to make an excellent pair, with attractive finish, interesting circuitry, printed circuit boards, and makers' six months' guarantee. As will have been noted in last month's issue Ed. Johnson can accept orders and will give details of U.K. prices and availability. If interest warrants we will arrange with Ed. for a full test.



NEWS FROM . . . . . . AMERICA

TRANSISTORISED servos and Relayless Receivers are causing a revolution in American R/C modelling. Unfortunately all the manufacturers have a different approach, especially with transistorising servos, some use three transistors, some four, and some six. Here are all details available at the moment. U.S. retail prices ($2.80 = £1). Orbit as used by Bob Dunham at World Championships. Release date November 15th.

Receiver and 10-channel Reed Unit, $69.95.
Power Pack and Charger, $39.95.
Receiver and Power Pack comb. $100.
Standard 10-channel Tx., $108.50.
Complete 10-channel System, $356.

Full details still not available but servo, as far as I know, is Bonner Duramite converted by Bob Dunham.

Power Pack is encapsulated, contains Deac cells, Transistor Converter for Receiver H.T. (Deacs power servos direct) and recharger unit for Deacs from Mains.

Bonners' Transistorised Duramites, will be called Transimites, available mid-October, contain six transistors. (This does *not* require split reed bank) $29.95.

Neutralising Servo, retail, $29.95.

Non - neutralising (Trim) Servo, retail, $27.95.

Amplifier Board (for converting Duramites to Transimites), $19.95.

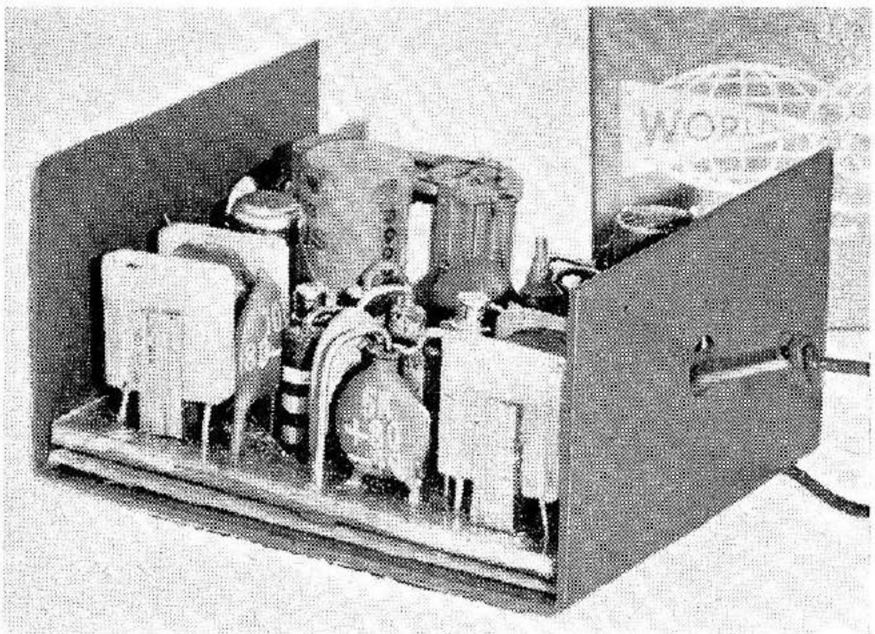
Don Steeb, of Steeb Atlas servos has a servo working on just three transistors, but no other details are available.

The servos, used in Solidtronics space control, are available separately. Retail, $29.95. Weight 2½ ozs., five transistor amplifier. German Micromax motor. 2 in. lbs. torque.

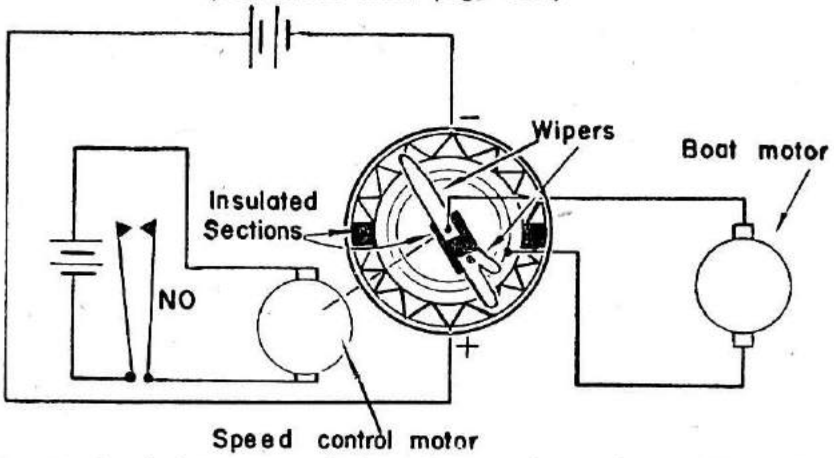
Twenty-three of the top U.S. Multi fliers accepted an invitation from the Radio Control Club of Detroit to a two-day meeting on September 10th-11th. Bob Dunham was first with Voltswagon. A.U.W. now 7¼ lbs. Ed. Kazmirski second because his mechanic called a manoeuvre out of sequence. Ed. K. used Orion to be kitted by Tip-Flite. Release date, October 19th, price $27.50.

Week-end before at a North Carolina contest, Bob Dunham flew inverted—read this carefully—10½ feet lower than *Radio Control Models* said he flew at Dubendorf. Result — no rudder, no fuselage top—!

Other relayless receivers (with Reed units) available soon.



(Continued from page 357)



neutral, right, *stop*, left. Operation of these contacts was effected by the crankpin on the star wheel.

The desire to incorporate a circuit for reverse led to modification number two; it was then possible to steer whilst the motor was in reverse.

A double pole change over relay was placed in the motor circuit and operated via a pair of normally open contacts fitted, this time, so that an insulated striker on the escapement armature closed them each time it moved towards the coil; i.e. on signal. This has the effect of holding the motor in reverse whilst the signal is continued, steering now requires OFF keying to change course or stop.

It was found necessary to fit a capacitor across the relay to avoid momentary switching of the reverse circuit whilst in the normal keying sequence.

This method gives complete control over steering, stop and reverse with the minimum of trouble and expense. The signalling system is extremely simple, commencing from the STOP position, the first brief signal switches the motor ON and AHEAD, and with the present arrangement, selects RIGHT rudder. Steering from then on is accomplished in the normal way with further brief signals, but remembering that the sequence is now RIGHT, STRAIGHT, LEFT, STOP (with rudder straight). To engage reverse, from any position *except* STOP, all that is required is that the transmitter be keyed continuously for the whole of the period that reverse is required. Steering can be obtained by releasing the keying-switch for brief periods, thus allowing the escapement to operate. From the stop position it is necessary to key briefly once in order to switch the motor ON, and then key continuously to change over.

Since operating these systems, it now seems possible to effect control over the motor speed. Whilst modification number three is still in theory only, there seems little reason to suppose it will not operate in the manner hoped for.

Instead of the armature-operated contacts energising a relay, it is proposed to use them to switch on a small electric motor, well geared down. The shaft of which will be coupled to the wiper of a wire-wound variable resistance.

This resistance will in fact comprise two windings, separated from each other with a neutral band (to give stop control) and the main drive battery will be wired through each of the windings so that polarity of the supply to the motor will be reversed, thereby giving reverse.

Made and printed in Great Britain by Bletchley Printers Ltd., Central Gardens, Bletchley, Bucks, for the proprietors, Model Aeronautical Press Ltd., 38 Clarendon Road, Watford, Herts. Published by The Argus Press Ltd., 8/10 Temple Avenue, London, E.C.4, to whom all trade enquiries should be addressed. Registered at the G.P.O. for transmission by Canadian Magazine Post.

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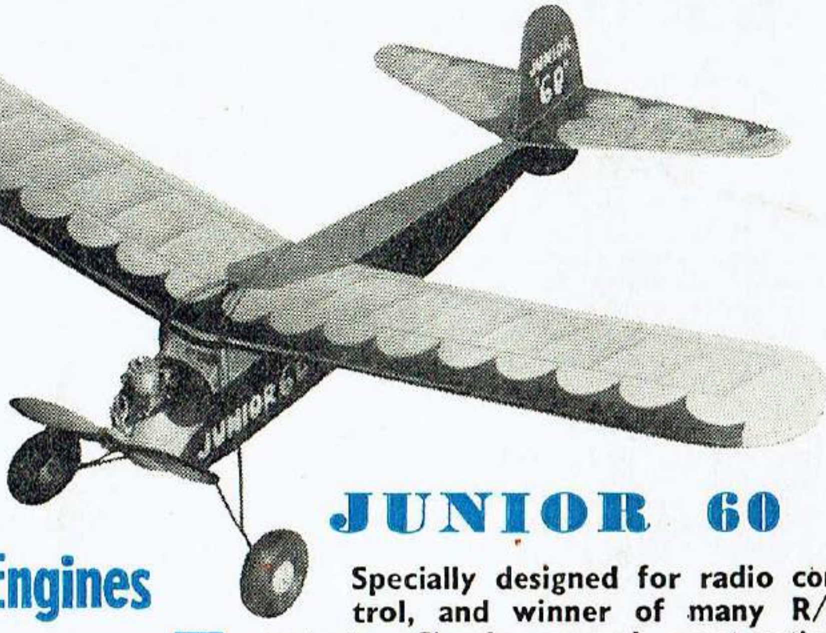

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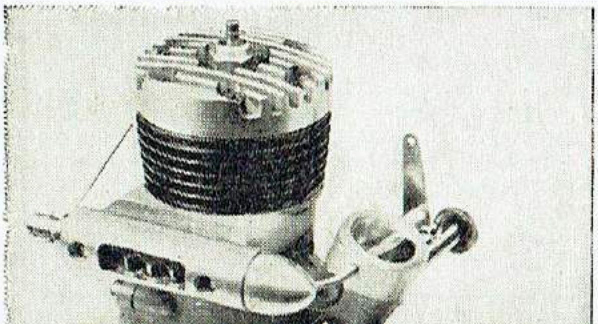

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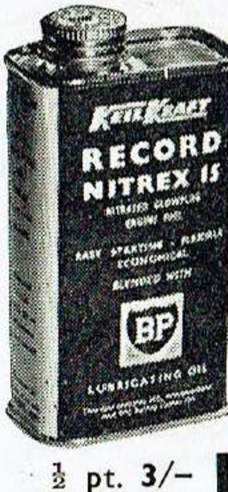

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