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# TRANSISTOR CIRCUITS FOR RADIO CONTROLLED MODELS



BERNARDS RADIO MANUALS

# TRANSISTOR CIRCUITS FOR RADIO CONTROLLED MODELS

BY HOWARD BOYS

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C.M.S.

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# INTRODUCTION

A number of books have been written about radio control for models, covering the whole subject very well. This book has been written to cover only the aspect of transistor circuits and so will, in no way, outdate previous books.

The writer wishes to pay tribute to the many people who have helped with material for this book, and these are mentioned in the text. All are radio control modellers, some well known and some not so well known. Another one who is not a modeller or radio man and not mentioned in the text is Mr. David Simons of Rugby who has personally helped with suggestions and tests.

Mention should also be made of Mr. Paul Runge of Ace Radio Control who runs the magazine "Grid Leaks" and to Mr. Laidlaw Dickson of Model Aeronautical Press who run "Radio Control Models and Electronics" and the "Aeromodeller", who have been so friendly in the way they have given permission for circuits published in their magazines to be used in this book. Without such help, such a book would be impossible, and this help given

so freely shows the great friendliness that exists among radio control modellers. The writer has not seen more friendliness anywhere than at the International Contests for Radio Controlled Model Aircraft.

Nearly all the circuits in this book have come from aircraft modellers, because the writer is more in touch with these, and it is natural that such people would be quick to investigate transistors for opportunities of reducing weight. Such circuits can be used just as well for boats or other models, since they will all benefit to some degree by a reduction in weight and space.

The writing of this book has been both interesting and instructive, as a fair amount of experimental work and studying of other peoples circuits and ideas had to be carried out. It also formed an excuse to visit the World Championship Contest at Zurich in July 1960, which resulted in two or three of the most interesting circuits. (This trip made a very good holiday with two extra days in Switzerland and two in France on the way back.)

*Howard Boys*

*LICENCE*

A licence is needed for operating radio control equipment. An application form and particulars are obtainable from Radio Branch, Radio and Accommodation Dept., G.P.O. Headquarters, London, E.C.1. It costs £1 for five years. No tests are required.

In Great Britain the band of frequencies allowed for radio control of models is between 26.96 and 27.28 mc/s. All the equipment in this book is suitable for this band, and the coil windings are suitable unless another frequency is quoted as in the case of the Austrian receiver. Most countries allow this band or part of it to be used.

*TRANSISTORS IN GENERAL*

Transistors differ in operation from the valves that have been known in radio for so long, but they can, in some cases, perform the same duties, usually with greater economy. Then again transistors can perform some functions not readily performed by valves.

There are many different transistors but, as far as radio control is concerned, they fall into three main classes. The most used are for audio frequency or D.C. amplifiers, the next for switching purposes and the last for radio fre-

quency. These last are rapidly gaining ground, and are fast replacing the subminiature valves that have been used so much for the super-regenerative detector stage in receivers using valve or transistor audio amplifiers. The transistors used for switching are now beginning to replace relays in different receivers.

There is quite a variety of shapes among transistors, but nearly all the smaller ones have three wires projecting from the bottom, a Collector, Base and Emitter, and they are shown in Fig. 1. The S on one is an interlead screen and connected to the metal case, and is usually earthed.

In the last four or five years, transistors have revolutionised the radio control of models, and with improved types always coming along they seem to be forging ahead by leaps and bounds. They are not only replacing valves, but also relays, and are making new techniques possible. With some of the new types coming along, prices of some of the older ones are being reduced. When this book was started a transistor suitable for use in a super-regen. receiver cost about £2. Halfway through another was available at 7/6d. and a little later an improved type was available suitable for economical use in transmitters.

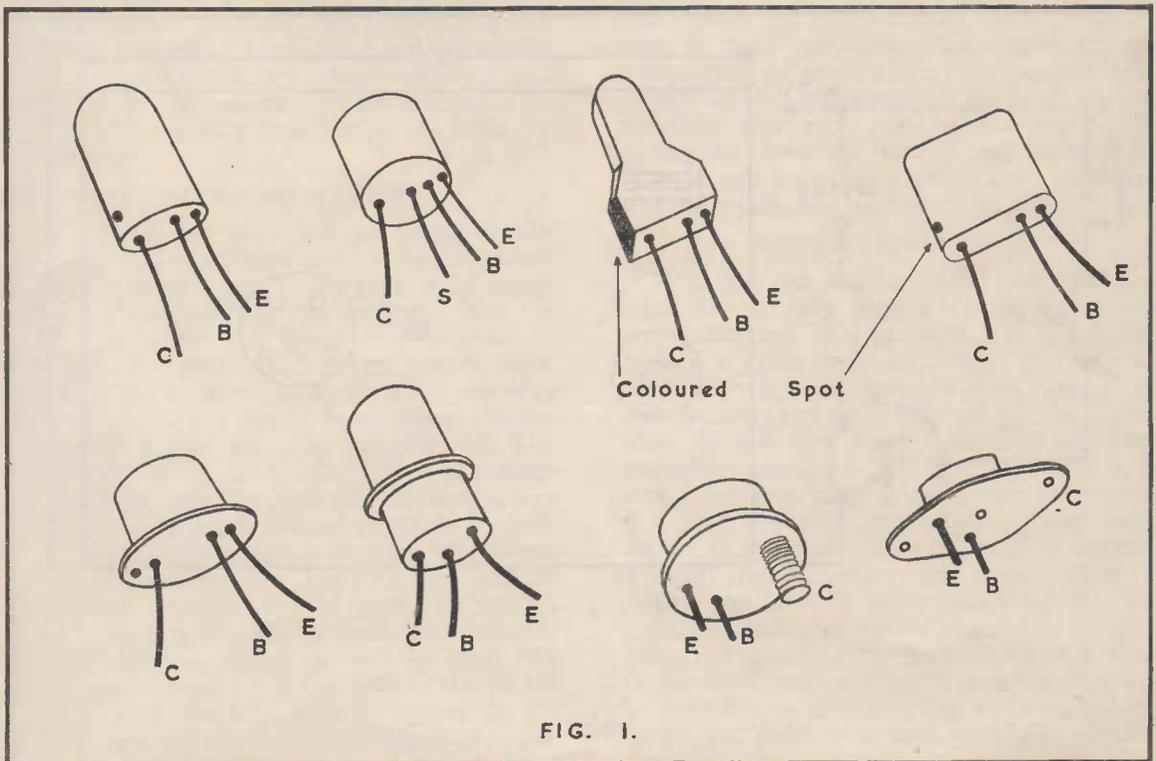


FIG. 1.

Transistors can be plugged into holders, or soldered into the circuit. At all times care must be taken to avoid getting a transistor hot. The soldering iron must not be brought too close, and when soldering a lead the wire should be held with a "heat shunt". This can consist of two pieces of copper fixed in the jaws of a small "alligator" clip or something similar. What is needed is something to conduct the heat away from the transistor and even two strips of copper or aluminium held together with a rubber band will serve. A small soldering iron which is really hot is best, so that the joint is made quickly without there being a large hot mass about.

Various holders are available as shown in Fig. 2 some for three leads and some for five. These latter can also be used with subminiature valves. On some will be found a very small "pip" which can be used to denote the collector, to match up with the coloured spot. Note that this coloured spot is sometimes red, but that does not mean positive.

While thinking of such misleading marks, it is perhaps as well to mention that some low voltage condensers have a small black bung in the positive end. With these the case is negative.

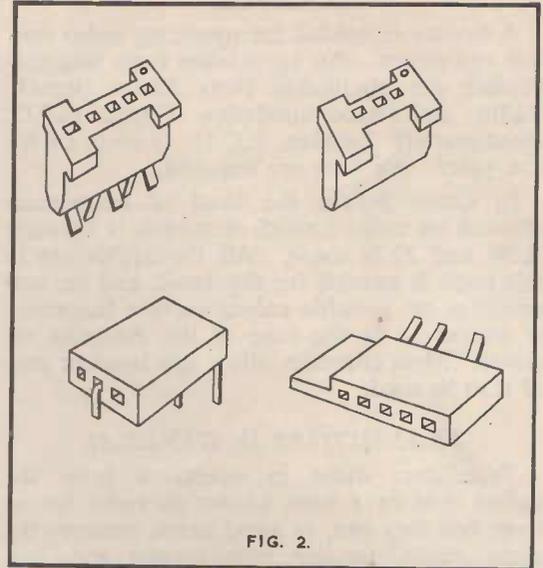


FIG. 2.

Due to the necessity of selling transistors at a reasonable price, coupled with difficulties in manufacture, a fairly large tolerance of characteristics has to be accepted. This variation is referred to as "Production Spread". In most circuits this is not important, but some-

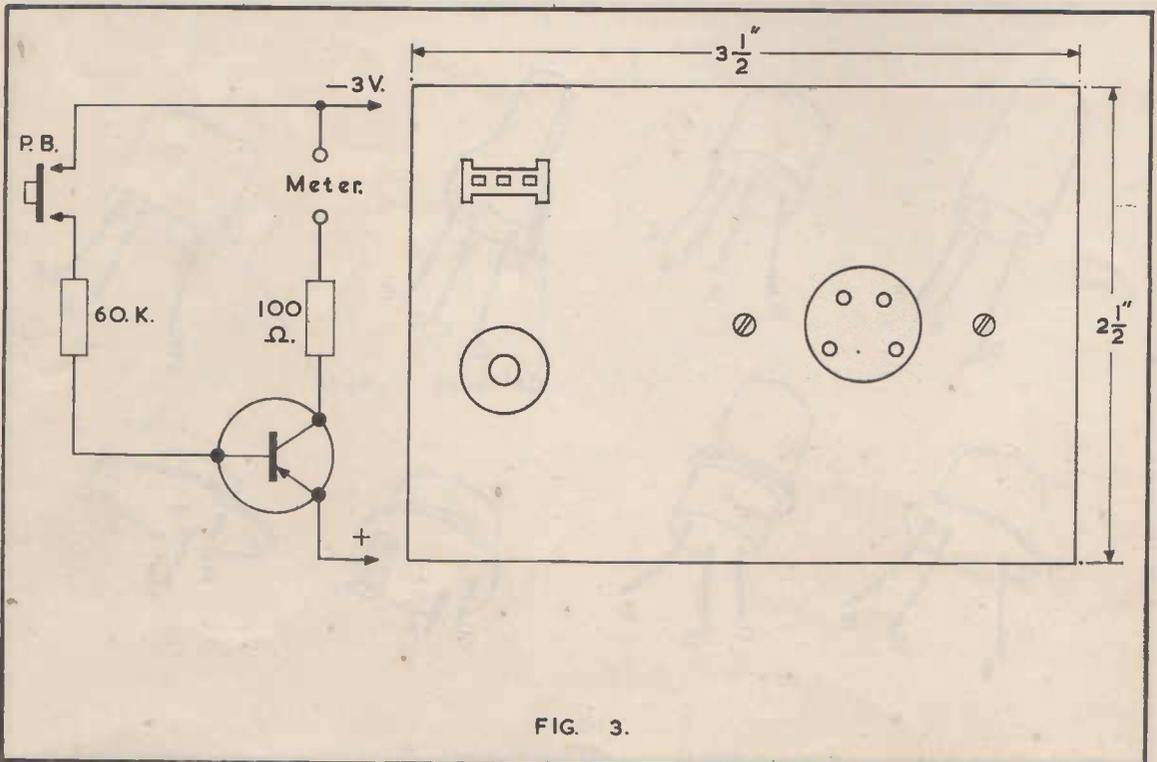


FIG. 3.

times a circuit can be improved by experimenting to find the best component values to suit the particular transistor.

#### A TRANSISTOR TESTER

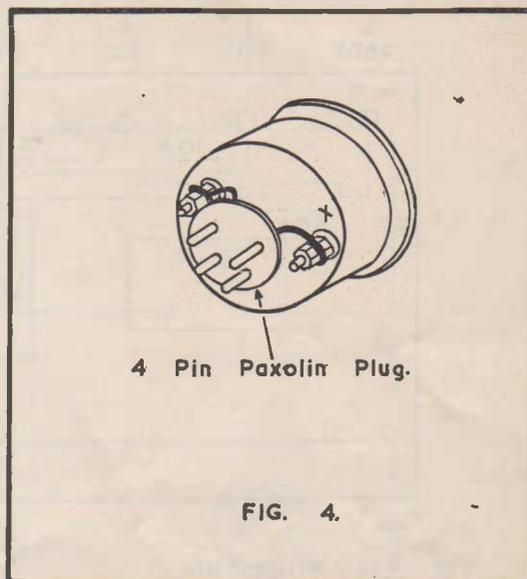
This is a handy piece of equipment for the experimenter and in this simple form, although not really accurate, does give a good idea of the two main characteristics of a transistor. This very simple circuit was thought up by David McQue, and the writer has put the bits on to a convenient panel layout. Fig. 3 shows the circuit and the layout. One hole is required for whatever holder is used, another hole for a push button, and other holes for a four pin paxolin socket. Into this socket is plugged a five milliamp meter (see Plugged Meter) which acts as a switch. The battery is two pen cells wired in series which may be soldered into the circuit.

After wiring up, a transistor can be plugged in, making sure it is the right way round. Some transistor holders have a tiny spot on the surface at one end, and if this end is made the collector end, then the spot on the transistor can always be lined up with the spot on the holder. With the meter plugged in the leakage current can be read though it may be very small. If the push button is now pressed the reading will go up. If this value in milliamps is multiplied by 20 the result will give the gain. In this way the transistors can be sorted out for different purposes. Low gain types are usually quite good enough for multi-vibrators and higher gain units can be used for amplifiers.

The panel is best boxed in at the back for protection.

#### PLUGGED METER

Meters are necessary for test purposes with radio control equipment and the usual scheme is to fit a suitable plug to the back of the meter used in connection with the receiver. Over the years the writer has found it convenient to have similar plugs on all the meters used. Whereas the usual modeller fits a two pin plug on the meter, the writer being more enthusiastic fits a four pin plug (see Fig. 4). The reason is this: in the simple receiver the meter is used to measure the high tension current, and therefore a socket is needed in the H.T. lead. This socket then needs a shorting plug when the meter is not in use. Then for switching on and off, something is needed in the low tension lead. If a four pin plug is used, two pins will feed the H.T. to the meter, and the other two pins can be shorted and that side of the socket connected in the L.T. lead. Plugging in the meter then switches on the equipment. For operating the model without the meter, a short-

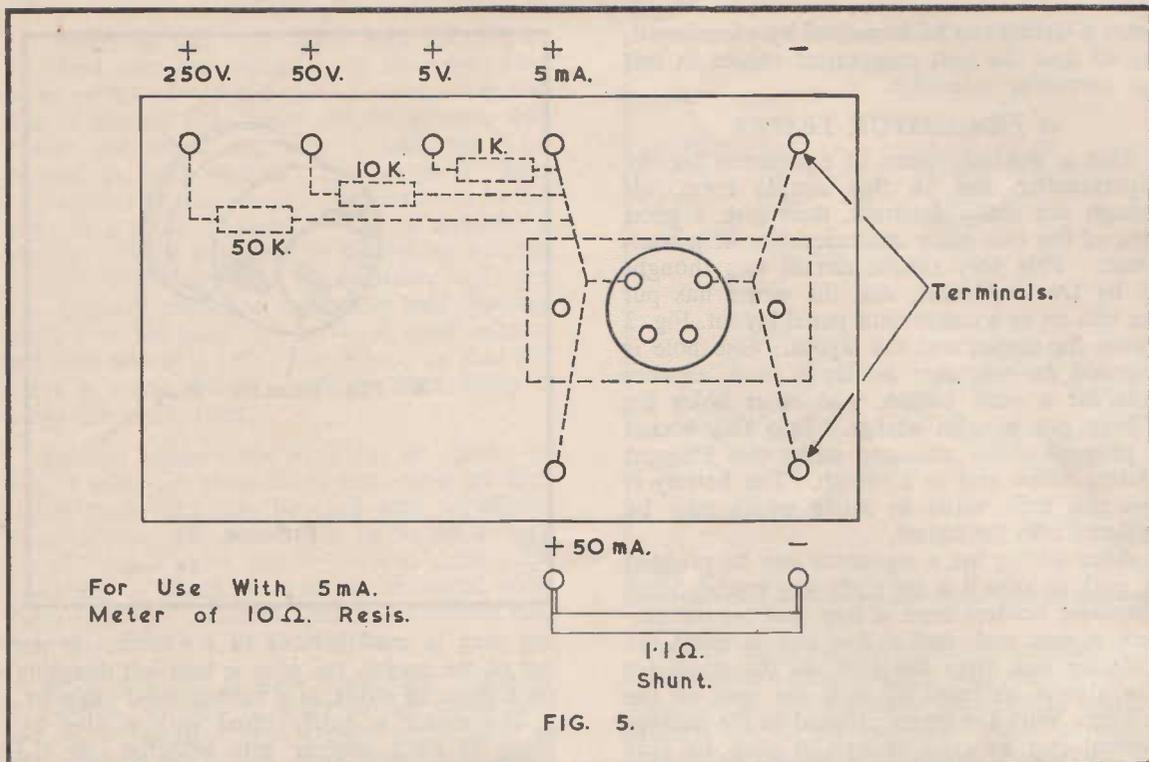


ing plug is used instead of a switch. When out of the socket, the plug is best left dangling on a piece of string or a rubber band close by.

The meter is easily fitted with a plug by using 18 s.w.g. copper wire soldered into the pins and then bent round the connection screws at the back of the meter. It is best to wrap these wires with insulating tape. Paxolin plugs and sockets are recommended, the types being seen in the illustrations. The meter for use with a receiver using a relay will usually need to read up to 5 milliamps. If the relay is a low resistance type used in a circuit of say 9 volts or less the meter will need to read up to about 30 m.a. and for convenience it may be necessary to obtain one reading to 50 m.a.

#### METER ADAPPTIONS

More than one meter has been mentioned, but when starting radio control it is likely that only one meter can be purchased. It is possible to buy a multi-range instrument that can be used for volts and amps of both transmitter and receiver, but a suitable one will be expensive. In this case many a beginner will need something cheaper. The best plan then is to buy a sensitive moving coil meter reading up to  $\frac{1}{2}$ , 1 or 5 milliamps depending on how much money is available. This can then be adapted with the aid of resistors and shunts. The resistors enable volts to be measured and the shunts allow higher values of amps to be measured. To take a simple case, with a 5ma. meter fitted with a plug, a panel or box can be provided, as shown in Fig. 5 with a suitable socket and resistors to read volts. The resistors should be close tolerance types, and the meter



will then be fairly accurate and at least good enough for most purposes. The resistance of the meter is usually marked on the dial, and to make it read 50 ma. instead of 5, a total resistance of 1/10th of the meter resistance will be required. If the meter resistance is 10 ohms, then the shunt will need to be slightly over 1 ohm. This can be provided by a yard of 38 s.w.g. (.006) copper wire. For accuracy the length should be adjusted with a properly calibrated meter in series. If enamelled or cotton covered wire is used it can be wound on a rod such as  $\frac{1}{4}$ " dowel and the ends soldered to thicker pieces of wire pushed through the rod for support. This shunt is then connected across the meter terminals, at the same time as the leads, for readings up to 50ma.

Note that in the instructions for tuning the Darkeagle transmitter, a meter reading one volt with a minimum resistance of 1000 ohms is required. It would be possible to use this meter on the 5 volt terminals, but it would be a little difficult to read fractions of one volt.

If a meter is used, having a full scale deflection of .5ma and a resistance of 500 ohms, different resistances and shunts would be needed. The resistance to make this meter read 1 volt would be 1500 ohms in series. To make it read 5 ma. a shunt of 55 ohms would be needed, and for 50 ma. a shunt of 5-5 ohms.

### FIELD STRENGTH METER

This is basically for measuring the strength of the radio frequency field radiated by the transmitter. It can also be calibrated to indicate the frequency of the radiation. It is quite simple, just a crystal set with a transistor amplifier, so that the usual 5 ma. meter or a small loudspeaker can be operated. A four pin socket is again shown for convenience when using the meter or a speaker fitted with a matching plug. Plugging in one of these acts as a switch. If desired, the meter and speaker could be fitted into the same case as the rest of the components. Switches would then be needed to switch the battery on and to switch to the meter or speaker as needed. Fig. 6 shows this switching as well as the whole circuit.

The tuning coil is made by winding 13 turns of 18 s.w.g. wire on a  $\frac{1}{2}$ " diameter paxolin tube, the wire being wound close, and then stretched to a length of 1". It is tapped at 4 and 11 turns as shown. The tuning condenser is 5pf. or less and fitted with a pointer knob. A trimmer with a maximum value of 50 pf. is also fitted, and this can be a ceramic or compression type. The coil can be mounted about half an inch from the tuning condenser using the 18 s.w.g. wire for rigidity. The trimmer can be soldered across the tuner. The tuning condenser and meter socket are mounted

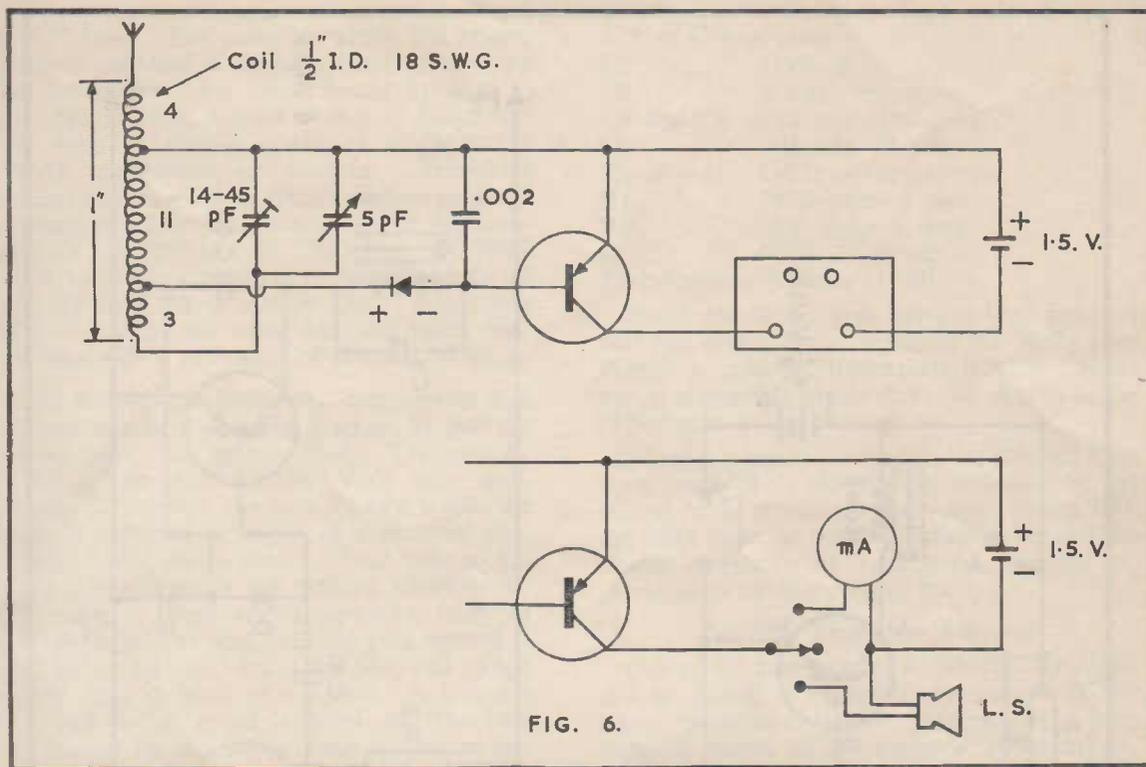


FIG. 6.

on a panel, the other parts being fixed at the back and boxed in. A socket or terminal should be provided for connecting the aerial which is just a foot or two of wire fixed vertically. The battery can be permanently soldered into the circuit since its life will be about equal to the shelf life. A pen cell will be quite big enough.

The meter and transmitter should be a yard or two away from each other before the meter is switched on. The meter should be calibrated from a crystal controlled transmitter, but for full calibration a crystal for each end of the band is needed. This will normally mean enlisting someone's assistance. However, given a suitable transmitter, tuning the meter is quite simple. The tuning condenser is set with the vanes half meshed and the meter brought near enough to the transmitter aerial to give a slight deflection of the needle. The trimmer is then tuned to give maximum reading of the meter needle, moving the meter as far away as possible from the transmitter. The tuner should be rotated a bit to make sure the trimmer is correctly set. The pointer can then be marked for the particular transmitter frequency. If other crystals are available other positions of the pointer can be marked, but the trimmer must not be moved. When the meter has been set other transmitters can be tuned to it by

tuning the transmitter to give maximum reading on the meter. Also, by putting the meter at a set distance from the transmitter every time, a check can be kept on the strength of the radiation.

#### RECEIVER WITH CRYSTAL DETECTOR

When considering using transistors for the radio control of models, it is natural to think of replacing the valve used in the normal simple receiver. Unfortunately transistors cannot just replace valves in that way. For one thing they work a bit differently and for another they are costly when used at the radio frequency allotted for radio control. A crystal diode has nothing like the sensitivity of a super-regen. valve though it can be used for a range of a few yards. The best known circuit for this purpose is shown in Fig. 7. The front part is a conventional crystal receiver except that the crystal is opposite way round. This feeds the first transistor so that when a signal is received this transistor shows a small current change. It is actually a slight rise. This causes a greater current change, a fall this time, through the second transistor that is enough to operate a sensitive relay. A milliammeter in the circuit shows the current flowing. This can be removed after adjustments have been made. The tuning coil has 11 turns of 18 s.w.g. copper wire, wound on a former  $\frac{7}{8}$ " diameter and stretched

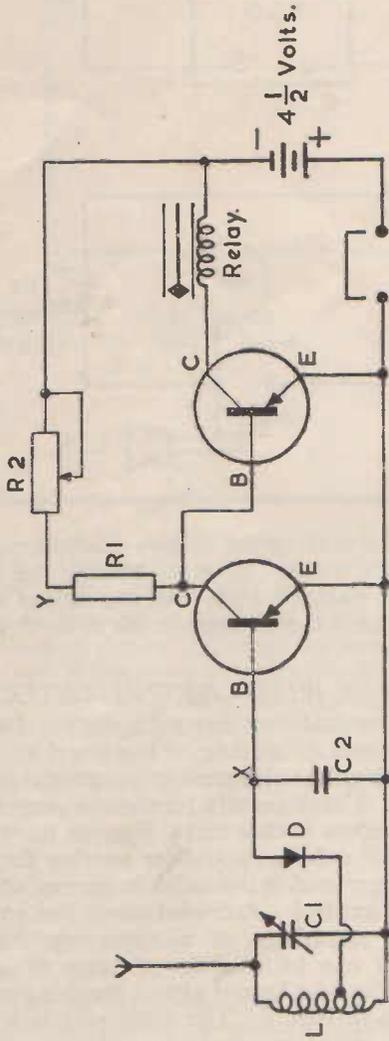


FIG. 7.

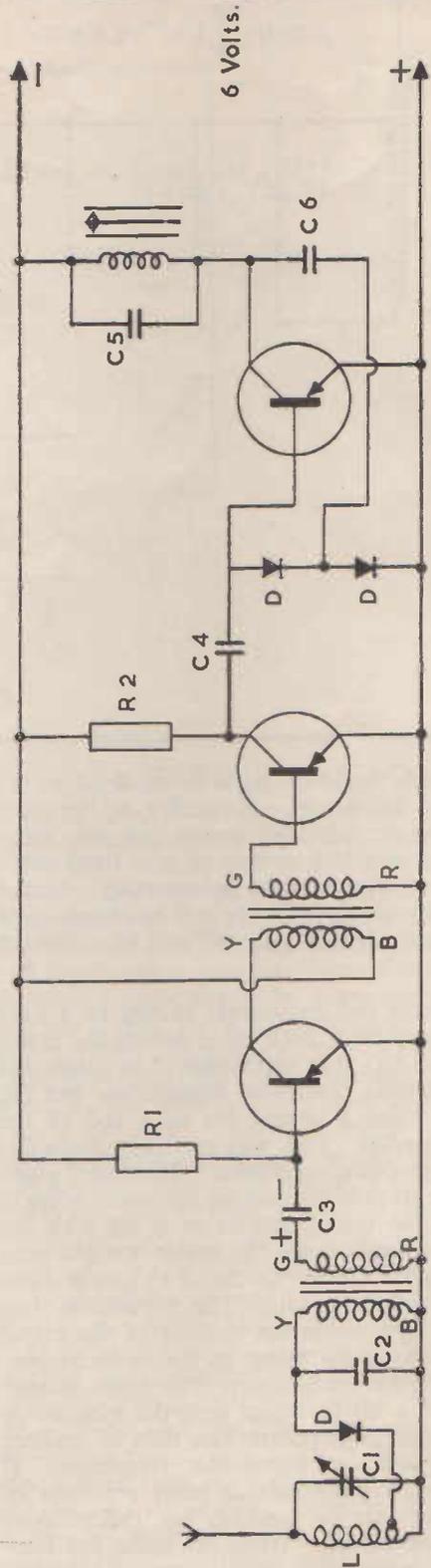


FIG. 8.

to  $1\frac{1}{4}$ " long. The point at which the crystal diode is soldered is about a third of the way up, the precise spot being found by trial to give the greatest current change. About the best type of tuning condenser (C.1) is the Philips concentric or beehive. Transistor holders can be used or the transistors soldered permanently into the circuit. Other components are C2 1000 pf., R1 20K ohms, R2 500K ohms variable subminiature advertised as G type, D GEX 34 or similar type. A suitable relay would be the usual sensitive radio control type with a resistance of about 5000 ohms.

The photograph shows the components laid out and wired up as in the diagram so that the various parts can be identified. The receiver in the photo did actually work very well, though in practice the components would be fixed to a board or panel of a material like paxolin. The photo shows a four hole socket for inserting a meter for making adjustments. The meter is fitted with a matching four pin plug and a similar plug with the pins shorted is used for normal working. This plug and socket can be used in place of a switch. A two pin plug and socket could be used, but the four pin is used by the writer since it enables the same meter and shorting plug to be used in other circuits and save a switch.

When the receiver is ready for test, the 500K variable resistor is adjusted to give a current of about  $\frac{3}{4}$  milliamp through the meter. The transmitter is switched on close to the receiver, and the tuning condenser adjusted to give a current drop. The tuning is then adjusted further from the transmitter, and the variable resistor adjusted to give best results, which vary according to the transistors used. Unfortunately, transistors cannot economically be made to close tolerances, and they often vary with temperature, so adjustments have to be made, and even then results will vary. Sometimes it helps if a 1 megohm resistor is put between points X and Y.

A better scheme is to use A.C. coupled transistors, which means modulating the transmitter with a tone. A suitable receiver is shown in Fig. 8. The tuning coil and condenser are the same as before, and the tap for the crystal diode is found in the same way. A transformer then couples to the first transistor through a condenser which allows the use of a stabilising resistor. Transformer coupling is used again, and then a condenser to the last transistor. Feedback is applied from the collector through diodes to the base and, with a 5,000 ohm relay with a 100 pf. condenser across it, the current change is 5 milliamps.

### List of Components

C2	1,000 pf.
C3	2 mfd. 150 volts.
C4 and C6	0.01 mfd. 150 volts.
C5	100 mfd. 12 volt.
Transistors	OC71 or similar type.
R1	100K ohms $\frac{1}{4}$ watt.
R2	10K ohms $\frac{1}{4}$ watt.
D	GEX 34 diodes.
Transformers	Ardente D1001.

Receivers of this type are not very sensitive and will give a range of only a few yards even though a powerful transmitter is used. However, it is possible to use them for models in the same room as the transmitter.

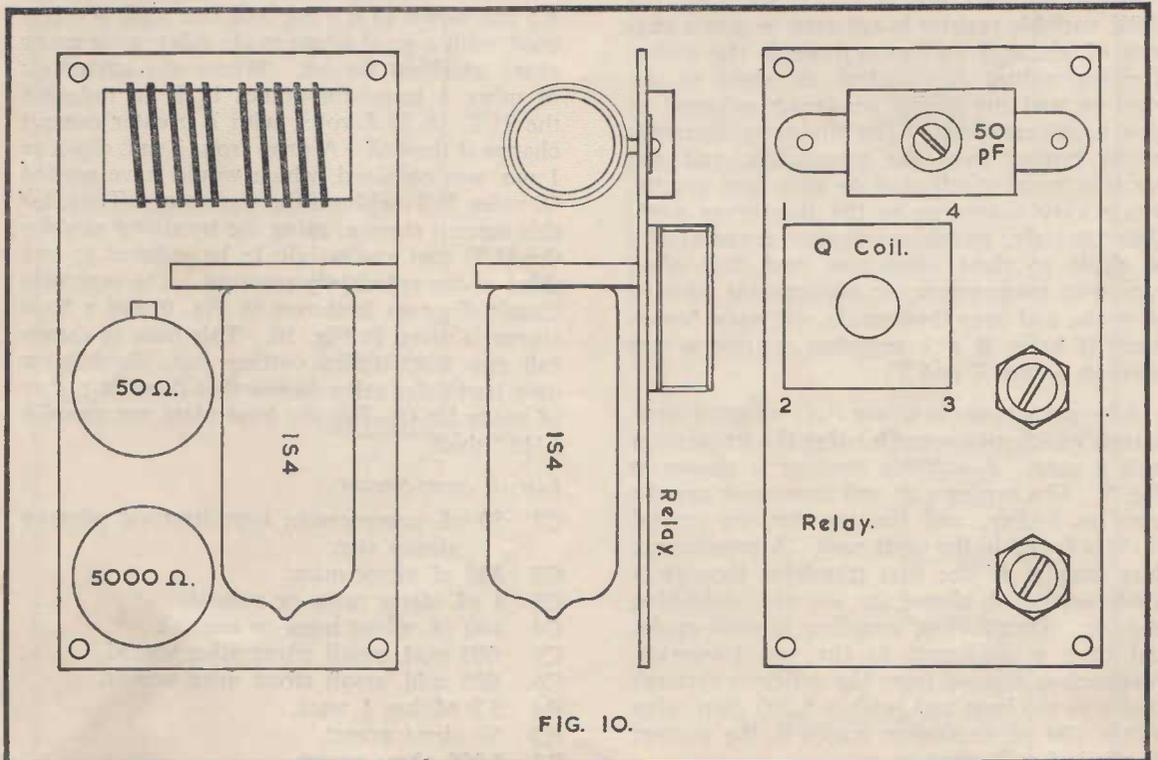
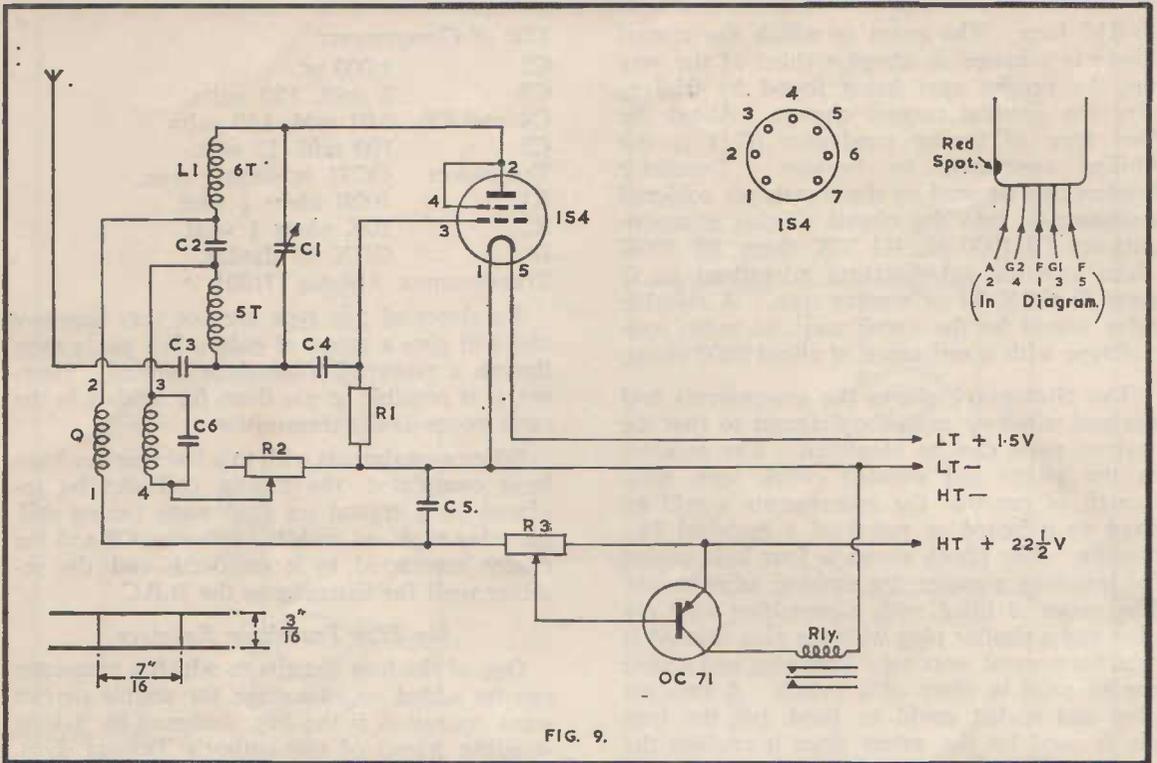
When experiments with this last receiver have been completed, the tuning coil can be replaced by a crystal set dual wave tuning coil, the relay replaced with headphones, C6 and the diodes connected to it removed, and the receiver used for listening to the B.B.C.

### Ivy Plus Transistor Receiver

One of the best circuits to which a transistor can be added to advantage for simple carrier wave operation is the Ivy, designed by a long standing friend of the author's Tommy Ives. The original circuit used 45 or 60 volts H.T. according to the sensitivity and current change required. With 45 volts the current was from 1.5 ma. down to 0.5 ma. and one such receiver used, with a good home made relay, gave many years excellent service. Where the advantage of using a transistor comes in is in reducing the H.T. to 22.5 volts, with a greater current change if desired. A drop from 3 ma. down to 1 ma. was obtained, which would have needed 60 volts, H.T. without the transistor. Thus, for this current change, using the transistor enables the H.T. cost and weight to be reduced to one third of the valve only receiver. The complete circuit diagram is shown in Fig. 9 and a base layout is given in Fig. 10. This base is shown full size but, before cutting out, check your own particular relay to see that there is plenty of space for it. For the base plate use paxolin  $1/16$ " thick.

### List of components

C1	50 pf. compression type trimmer postage stamp size.
C2	300 pf. silver mica.
C3	5 pf. silver mica or ceramic
C4	100 pf. silver mica or ceramic
C5	.003 mfd. small silver mica waxed.
C6	.005 mfd. small silver mica waxed.
R1	3.3 Mohm $\frac{1}{4}$ watt.
R2	50 ohms preset.
R3	5,000 ohms preset.



The relay can be from 3,000 to 5,000 ohms resistance. The tuning coil L1 is in two parts, but only separated by a small amount, see underneath view. It is wound on a piece of paxolin tube  $\frac{5}{8}$ " outside diameter and has 6 and 5 turns, as shown, of 18 or 20 s.w.g. copper wire, tinned or enamelled will do. It is best to wind the wire on a slightly smaller former leaving the ends quite long enough and then "screw" it on to the final tube. It should then be stuck in place with polystyrene cement. The quench coil Q is wound on a former made from paxolin tube  $\frac{7}{8}$ " diameter with side plates  $\frac{7}{8}$ " square, spaced  $\frac{3}{16}$ " apart as in the small view. On this is wound 500 turns of 42 s.w.g. enamelled copper wire, the start being marked No. 1, and the finish No. 2. Another 500 turns are wound on in the same direction the start and finish being marked No. 3 and No. 4 respectively. The wire ends are threaded through holes in the corners of the side plates, together with some short thicker wires, say 22 gauge tinned copper, about  $\frac{1}{4}$ " long. These are bent over to clip the former and the thin wires soldered on. The enamel can be cleaned off by carefully stroking with glass paper before soldering. A coating of polystyrene cement will finish it off. The completed coil is fixed to the panel with a screw through its middle but it must be brass and not steel. The tuning condenser is fixed with two eyelets or hollow brass rivets and a  $\frac{1}{4}$ " hole will be needed in the centre to clear the adjusting screw. The valve is a IS4 and plugs into a paxolin holder which is supported by an angle bracket on one side and a little bracket soldered to the 50 ohm variable resistor on the other side, the middle and one side tag being used for the purpose. The transistor is an OC71 or similar type, but many of the cheaper sub-standard types can be made to work satisfactorily. Wiring up is quite straightforward, but it is easiest if the connections to the valve holder are made before the coil is fixed. This is fixed in place by soldering the end wires to the tuning condenser fixings, leaving a space of about a quarter of an inch between the coil and the baseplate. The aerial consists of about two feet of plastic covered flex.

A receiver was also built and operated satisfactorily using a sub-miniature valve, but some of the components needed to be of different values. The actual valve used was a CK 507 AX, and the other values were as follows:—

- C1 100 pf.
- C2 500 pf.
- C3 5 pf.
- C4 100 pf.
- C5 .005 mfd.

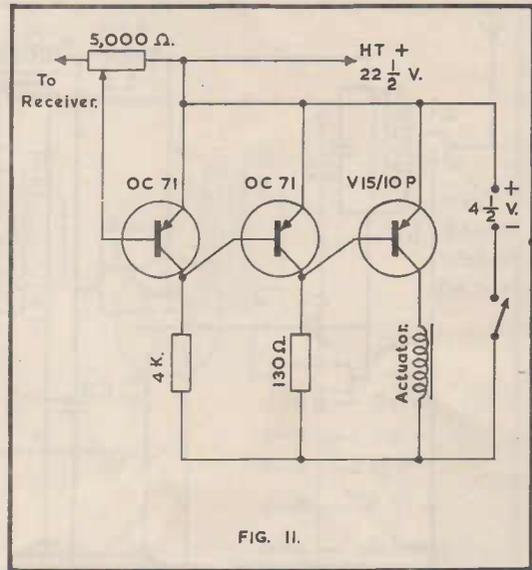


FIG. 11.

- C6 .005 mfd.
- R1 5 meg. ohms.
- R2 100 ohms.
- R3 5,000 ohms.

Valves such as the DL66, DL68 or DL72 are usually interchangeable in circuits of this type.

The valve base connections are shown for the IS4 and CK 507 AX. A 3S4 valve can be used instead of the IS4 by connecting pins 1 and 7 together.

In operating this receiver it is tuned to the transmitter with C1 and the sensitivity is adjusted with R2. R3 regulates the current flow through the relay. A double pole switch should be used in the HT + and LT - battery connections.

A variation on this receiver is to add two further transistors and dispense with the relay. The last of these is a power type and can handle as much as 3 amps, which is more than normal actuators require, and more than people like to use on account of the battery drain. A "Fly-ball" actuator with electric motor can be used for pulse proportional control, or a single acting magnetic type, or the usual escapement type. The extra circuitry is shown in Fig. 11, and it will be seen that the previous circuit is used up to the relay which is replaced with a 4K ohm resistor. The rest is quite straightforward.

### Tone Operated Receivers

Making use of tones to operate radio control apparatus introduces a little complication but has compensating advantages, particularly when using transistors. The transistors are less likely to be affected by temperature changes and the receivers are easier to tune.

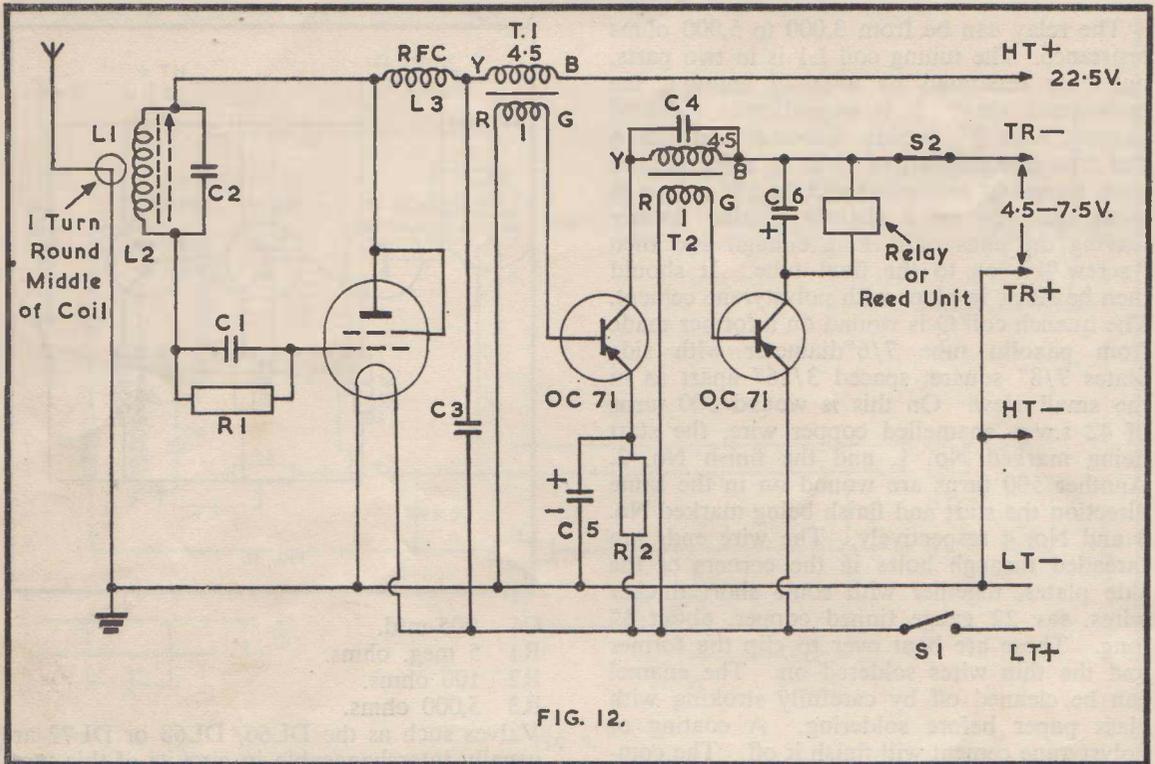


FIG. 12.

Fig. 12 is the circuit diagram of one of the most attractive receivers the writer has used. It is a tone operated receiver introduced by David McQue, and has been given the name "Quetone". The usual receiver using valve and transistors takes the transistor supply from the valve H.T. battery which seems expensive. The Quetone uses a separate low voltage battery for the transistors and in one version this battery is also used for the actuator. The valve uses very little H.T. so this battery can be the same size as a pen cell. A suitable panel layout is shown in Fig. 13 and the panel can very well be 1/16" paxolin or similar material. Thinner material can be used, but it is not so easy to handle.

*Components required are:—*

L1 which is one turn of the aerial wire round L2 which is 19 turns of 28 s.w.g. silk or cotton covered copper wire on a 1/4" aladdin former with a dust iron core. L3 is a radio frequency choke made by winding a CHI neoside choke core full of 32 s.w.g. enamelled copper wire. The ends of the copper wire are soldered to the wires sticking out of the core (one each end). C1 is 47 pf. ceramic or silver mica and C2 is 5 pf. similar. C3 and C4 are Hunts waxed, .003 mfd. and C5 is 10 mfd. sub miniature of 3 or 6 volt rating, though there are some small

enough at 25 volt rating. C6 is 5 mfd. for a 1,000 ohm relay or 25 mfd. for a 300 ohm relay R1 is 3.3 megohms and R2 is 3.6 or 3.9K ohms. The transformers T1 and T2 are hearing aid types 4.5:1 ratio, Ardenite T1079 or D1001. The valve is the Hivac XFY34 though various others work as well such as CK523, CK507, DL66, DL68 and DL72, though the filament current varies. The DL72 has the wires arranged differently but they can be carefully bent to fit into the small valve holders that take the other valves. The author has used all these valves with satisfaction. When building the receiver, holders can be used for the valves and transistors, or they can be soldered straight into the circuit. (Note: care required when soldering transistors.) Holders enable damaged or faulty components to be easily replaced, but soldering in makes for greater reliability. Holders are of differing types some being fixed in a slot in the panel, some can be pushed through a hole and some are bolted in place. Those that would normally require a slot can often be bound on with thread. The coil former is bolted on and the transformers can be bound on with thread or clipped in a turn of copper wire or fixed with a cement such as Araldite. Other parts can be held in place by their ends going through the panel. Very carefully check the wiring to make sure that there

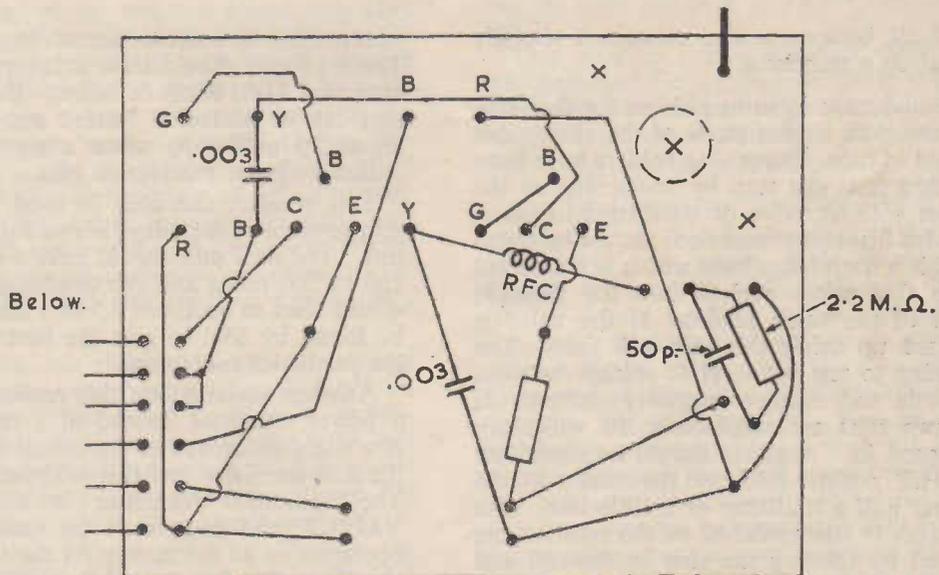
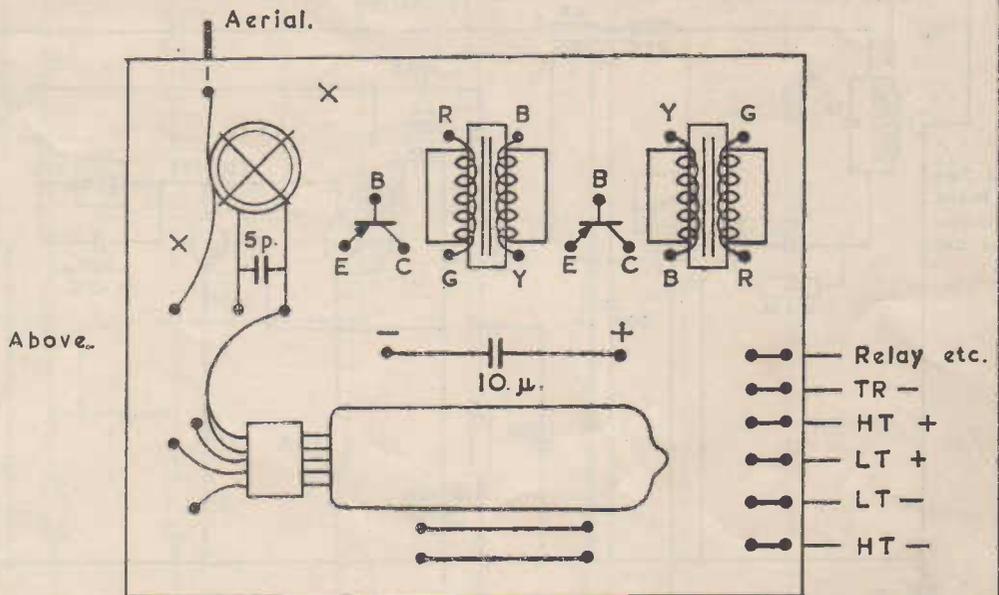
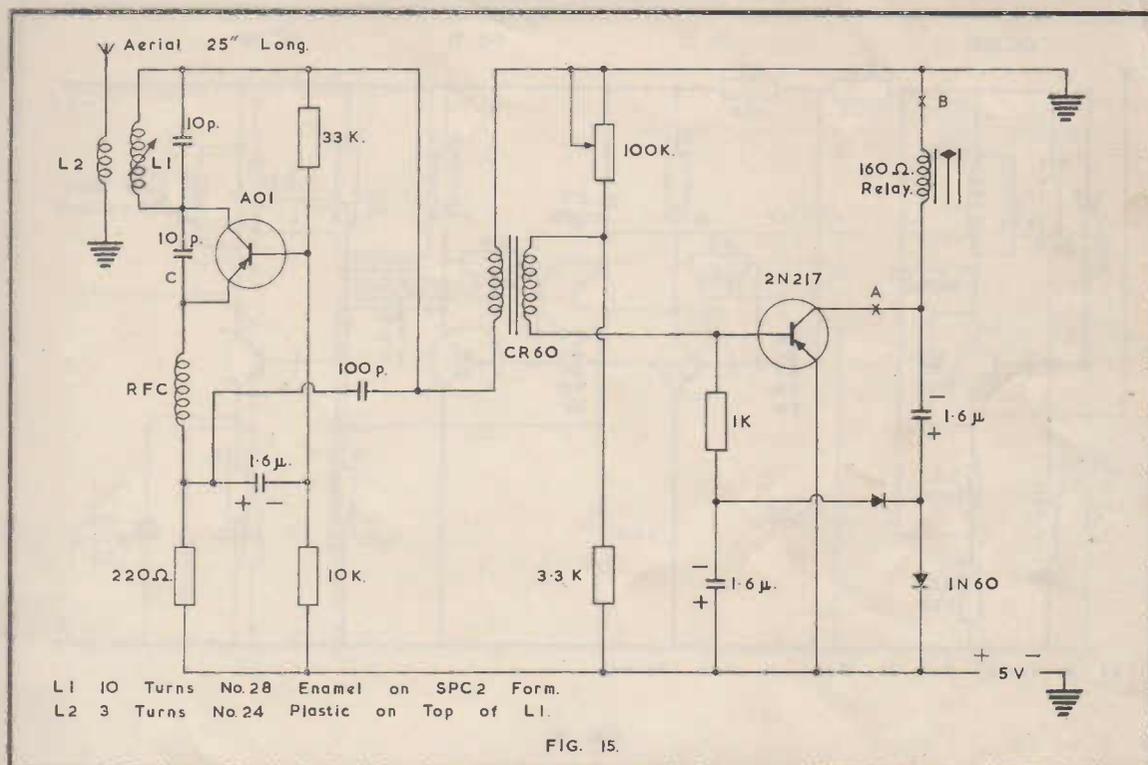


FIG. 13.





method, used by the writer is a four pole plug and socket. The socket is connected in the wiring to the receiver and a plug with shorting wires tied alongside. A meter with a suitable milliamp range is fitted with a similar plug, the meter movement being connected to the TR-supply pins to take the place of S1 and the other two shorted to take the place of S2. The connections to the socket must be the right way round or the meter will try to read backwards. A meter connected in this way enables the receiver to be tuned and checked conveniently at any time.

To operate this receiver, a tone transmitter is required, the carrier wave being switched on all the time and the signal being given by keying the tone. With a reed unit the tone will need to suit the reed, but with a relay or power transistor the tone can be between about 300 and 1,000 c/s. With the transmitter off altogether, some current will flow through the relay or actuator. If it is too much the .003 mfd. condensers can be increased to .005, or transistors with lower beta used.

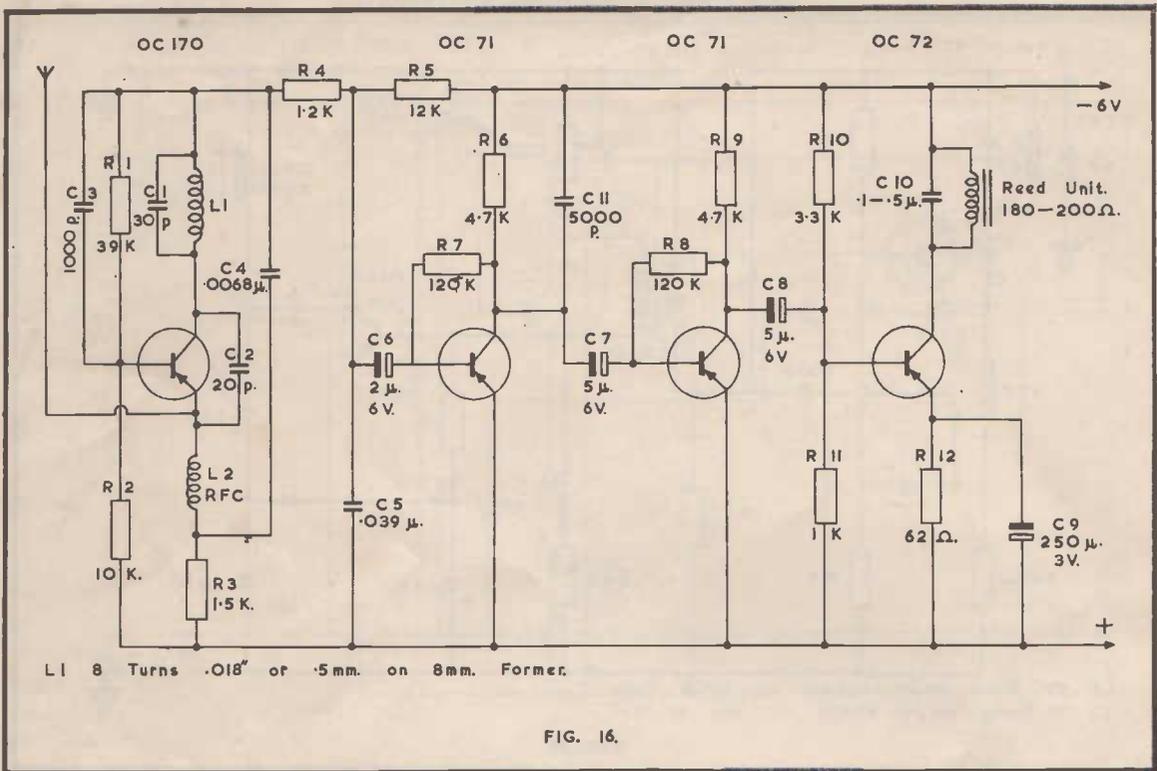
Final tuning is carried out by having the tone transmitted and tuning the receiver to give the greatest current as shown by the meter. If a reed unit is fitted, the transmitter tones must be tuned to the unit. For this operation the transistor supply should be reduced to 4.5 volts,

and the volts put back to 7.5 for normal operation.

This receiver circuit was first published in the *Aeromodeller* of August 1959, though in use by the writer and other friends of David McQue some time before that. It is considered well worth a place in this book.

#### *A Diminutive Receiver (Tone)*

This receiver (Fig. 15) is one after the writer's own heart and comes from Capt. Francis Plessier of France by way of America, by courtesy of "Grid Leaks" and is therefore their copyright. It was developed for the purpose of flying a model indoors and the overall dimensions worked out at 25 c 40 c 15 millimetres and weighed 28 grams. Capt. Plessier advises building it on the workbench first with variable resistors here and there for making adjustments. The output transistor was selected for as high a gain as possible because with only two transistors altogether, it was necessary to obtain highest possible efficiency. When built it is checked first with earphones at point A, for a rushing noise to indicate that the first stage is super regenerating. If not the condenser C must be increased until it does, but it should be kept as small as possible for maximum sensitivity. With the AO1 removed a meter is connected in the circuit at B and the 100K pot. adjusted to give about 3 ma. Insert the AO1 and if



oscillating correctly the current will go up slightly to about 3.5 ma. and the noise will be heard. With a modulated signal on, the current will go up to 15 or 20 ma.

The actuator used was a magnetic type very similar to the one described elsewhere in this book and a separate battery was used to avoid interaction. From much experience with actuators of this type, the writer believes that one wound to a resistance of about 150 ohms could be used in the transistor circuit direct, and thus make the relay and the actuator battery unnecessary.

With the receiver installed in a model and switched on, the 100K potentiometer should be adjusted to the point where the relay does not quite operate. Then the circuit will be most sensitive for operation from a tone transmitter. L1 should be carefully tuned some distance from the transmitter. This receiver was designed for flying a model indoors, and so a great range was not required. Tested outdoors with a powerful transmitter the range was about 300 yards, which is enough for a small model.

For those builders unable to obtain the American components, the following are suggested. For AO1 use SB305, SB344, XA131, OC169 or OC170. For 2N217 try V10/50A,

XB103 or OC76. For the transformer use a hearing aid type of 4.5 or 5 : 1. For 1N60 use GEX34 or D3/2/1Y. For L1 a former about  $\frac{1}{4}$ " diameter.

#### *A Conventional All Transistor Receiver (Tone)*

For a straightforward all transistor receiver, a circuit has been sent by Mr. Derk van de Wall of Holland. It is typical of its type (Fig. 16), and little comment seems called for. The condenser C10 is varied to suit the particular reed unit used. A relay could be used instead with a condenser of about 25 mfd. or a power transistor could be added.

If "production spread" should cause difficulty in getting this receiver to work satisfactorily, different values for C2 could be tried and a 50K ohm potentiometer could be used in place of R1 and R2 to find the best bias conditions. The resistance of this pot. each side could be measured afterwards, and two fixed resistors used finally. Note Capt. Plessier's suggestion for the diminutive rx.

#### *Power Transistor Switch*

In the Quetone receiver, a relay, reed unit or power transistor could be used with very little alteration. The power transistor then acts as an on/off switch that will take up to 3 amps. This will satisfy many actuating mechanisms

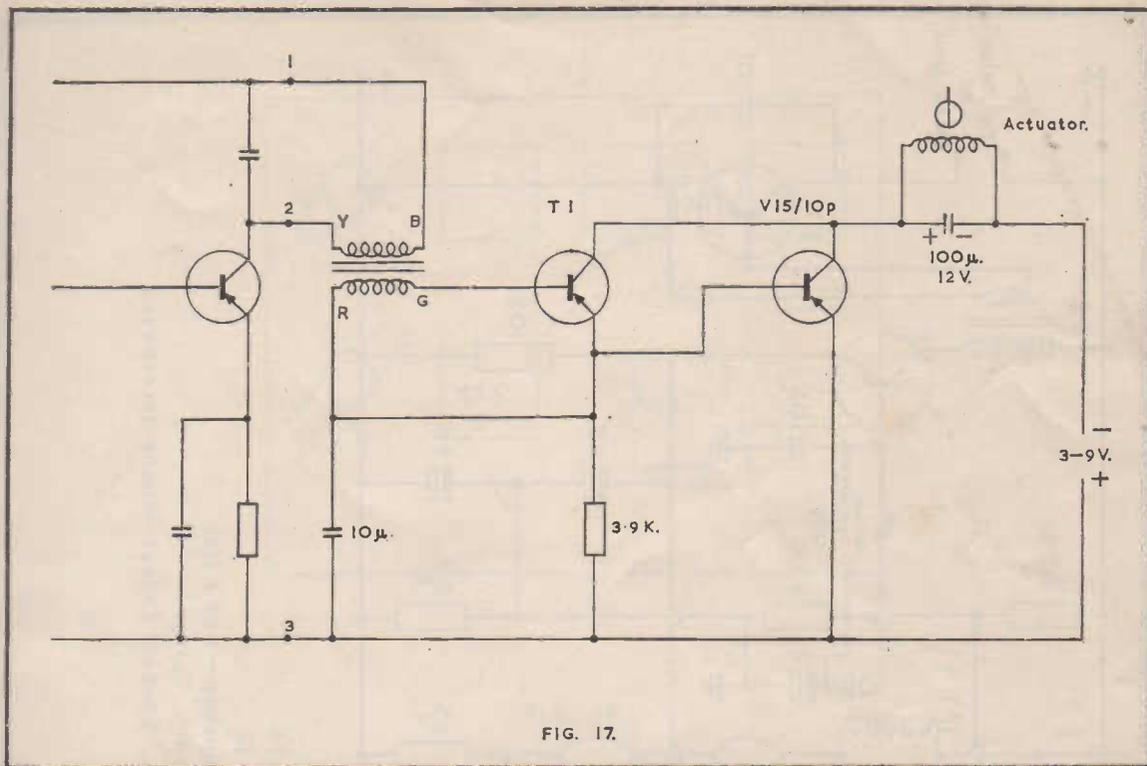


FIG. 17.

and has proved very reliable. The same scheme can be applied to other audio type receivers in the same way. Fig 17 shows the circuit of a complete unit than can be added to almost any of these receivers. In some cases T1 will not be needed, such as when the last transistor of the receiver is transformer coupled. The last stage can then be converted as shown. The transformer used was the Ardenite D1001 and the components built on a small piece of paxolin with flex leads to receiver, actuator and battery. If a heavy current is passed by the power transistor it would be better to bolt it to a piece of aluminium which should have the other components mounted on it, though some insulation would be necessary. The power transistor has a screw thread for its collector connection for the purpose of bolting it to a sheet of metal for a "heat sink". The current will depend on the actuator and the voltage.

Three connections to the receiver are required — 1 and 2 replacing the relay and 3 going to battery positive. T1 can be an OC72 type. If the last transistor in the receiver is transformer coupled, then the circuit can be converted, behind points 1, 2 and 3.

This is, of course, the back end of the Que-tone receiver.

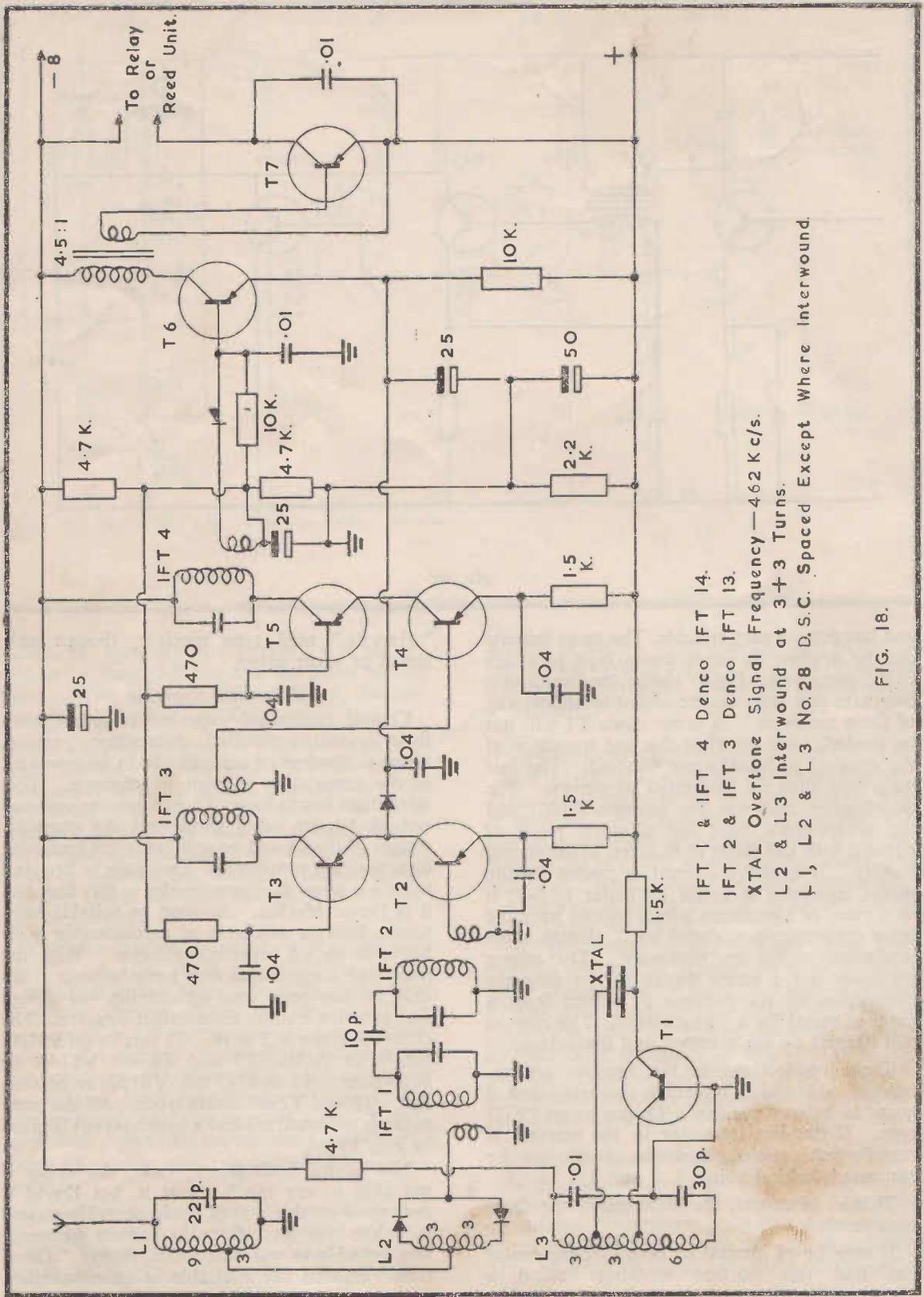
It may be of interest to note that the writer has had this portion working behind a

"Henry's" reed type receiver, though only tested at short range.

#### *Transistor Superhet*

Crystal controlled superhet receivers, with their crystal controlled transmitter partners allow a number of equipments to be operated at the same time without interference. This advantage has to be paid for in greater cost and weight, but by using transistors the complete weight of model and equipment is not increased by a very big proportion. One man in England has done more than anyone else in this line, and it is David McQue. As soon as suitable transistors became available at a reasonable price he built an all transistor receiver. With the improved components that have become available he has been able to simplify the design and produce a more economical receiver. The circuit is given in Fig 18. T1 can be an SB100, SB305 or AO1. T2 and T4 are V6/4R or equivalent. T3 and T5 are V6/2R or equivalent. T6 and T7 are audio types. All the components are standard and a rough layout is given in Fig. 19.

Not having built this receiver, the writer is not able to say much about it, but David is very good on this sort of equipment. He started superhets for aircraft radio control before it was possible to use transistors. Small "Over-tone" crystals are available at an economical



IFT 1 & IFT 4 Denco IFT 14.  
 IFT 2 & IFT 3 Denco IFT 13.  
 XTAL Overtone Signal Frequency—462 Kc/s.  
 L2 & L3 Interwound at 3+3 Turns.  
 L1, L2 & L3 No.28 D.S.C. Spaced Except Where Interwound.

FIG. 18.

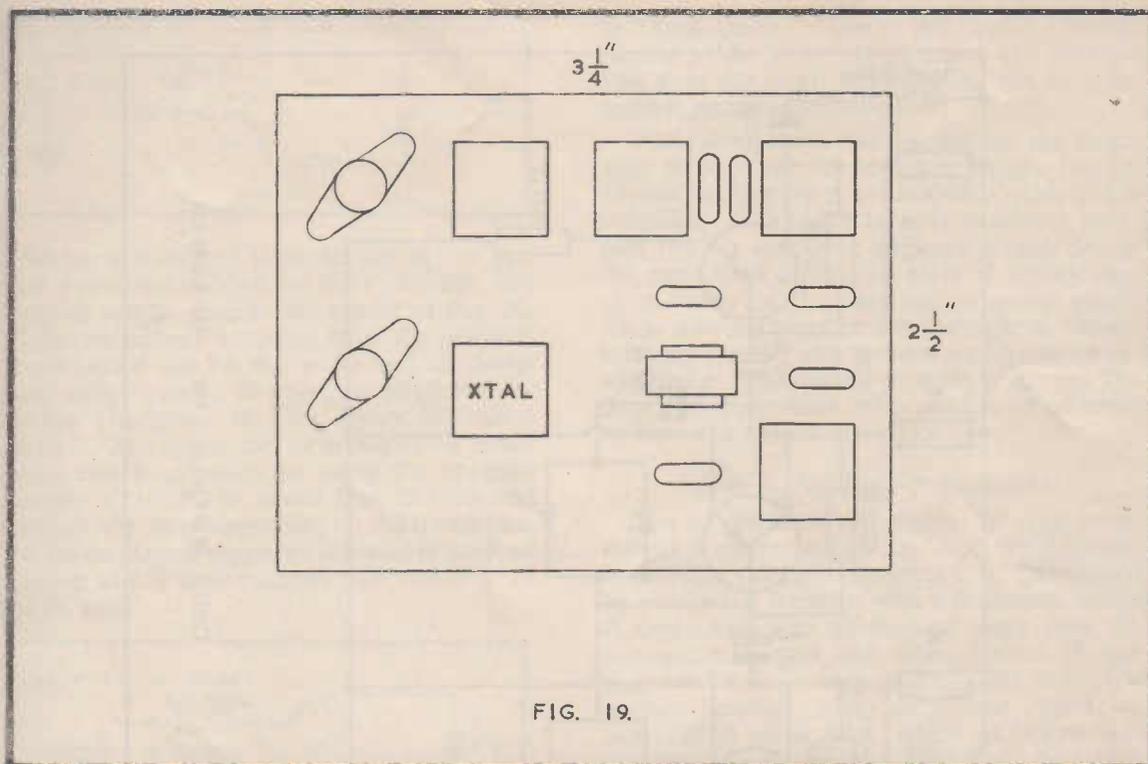


FIG. 19.

price and one manufacturer advertises them in suitable pairs for superhets.

Superhets will become more widely used as time goes on, meanwhile, here is a starting point.

#### *An Austrian Receiver*

This circuit, Fig. 20 was designed by Mr. J. Kastner of Vienna. Mr. Oskar Tollich uses it for controlling a model glider, and the two have been working together for many years to produce reliable equipment. The circuit was designed to use the first R.F. transistors such as the RCA 2N247 which would not function in the usual circuits, though later transistors such as OC170, OC171, OC615, etc., can be used. The tuning coils are wound on 7 mm. diameter formers with dust iron cores and the number of turns given are for 40.68 Mc/s. The choke CH is to keep the quench frequency out of the audio stages. The best type uses a small ferroxcube pot core wound with 1,500 turns but a headphone coil of 1,000 ohms will do.

The diodes in the A.F. stages are OA5, OA7 or OA9 though OA70, OA71 or OA80 will do. These form a "chopper" circuit to maintain a constant amplitude signal in the reed unit. This reed unit is condenser coupled to prevent the D.C. flowing through the winding. The A.F. transistors are OC71 or similar. The resistor NTC, is negative temperature coefficient

to stabilise the transistors against temperature changes. Altogether this is an unusual and interesting circuit.

The glider in which this receiver was fitted was used to give demonstration flights during the intervals at the World Championship Contest for Radio Controlled Power Models in Switzerland in 1960.

#### *Reed Operated Transistor Switch*

The usual method so far for operating a control from a reed unit has been to energise a relay from the reed. This resulted in a heavy drain from the H.T. battery, so when suitable transistors became available they were naturally investigated for the purpose of replacing the relay. About the simplest scheme is that in Fig. 21 in which a V15/10P transistor is used with a motor which can drive a "Flyball" actuated or be geared direct to the control surface. A spring or other force is required to return the control to neutral. One complete circuit as shown is required for each control function. The battery voltage will depend on the motor and power required. Note that starting current for a motor is high and transistors must not be overrun even for a brief period. There are smaller transistors that would take the normal current with the motor running but would break down on starting.



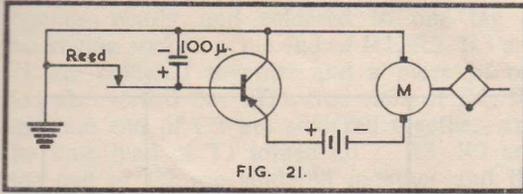


FIG. 21.

Where it is desired to make one motor perform two function such as right and left, two batteries can be used in the circuit of Fig. 22. While this follows naturally from the previous circuit sorted out by the writer and no doubt many other people, it was first published by George Thompson of New Jersey in "Grid Leaks". The motor can be arranged for either spring return or return by using the opposite control. C should be about 8 to 25 mfd. and R about 400 ohms depending on the transistors. If a centre tapped magnetic actuator is used, or a motor with a centre tapped field coil, Fig. 23 can be used.

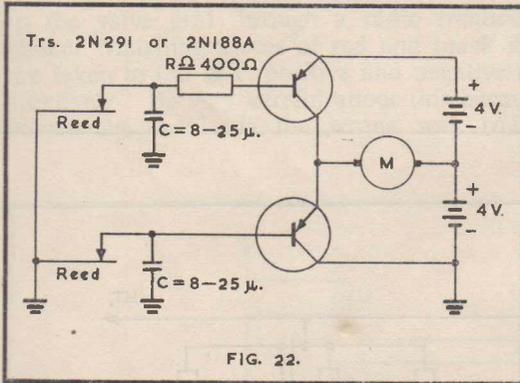


FIG. 22.

Different ways have been thought up by various people for electrically returning the motor to neutral position when the signal ceases. The circuit that appeals most to the writer shown in Fig. 24 was devised by William E. Savage of California, and was published with reservations

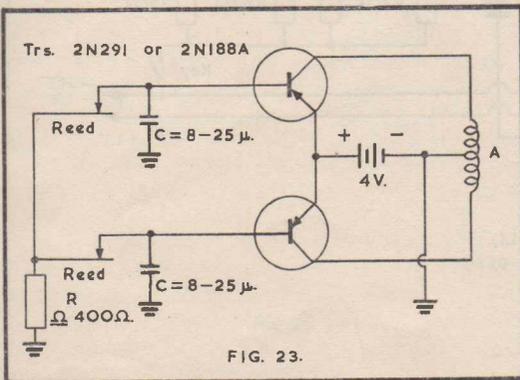


FIG. 23.

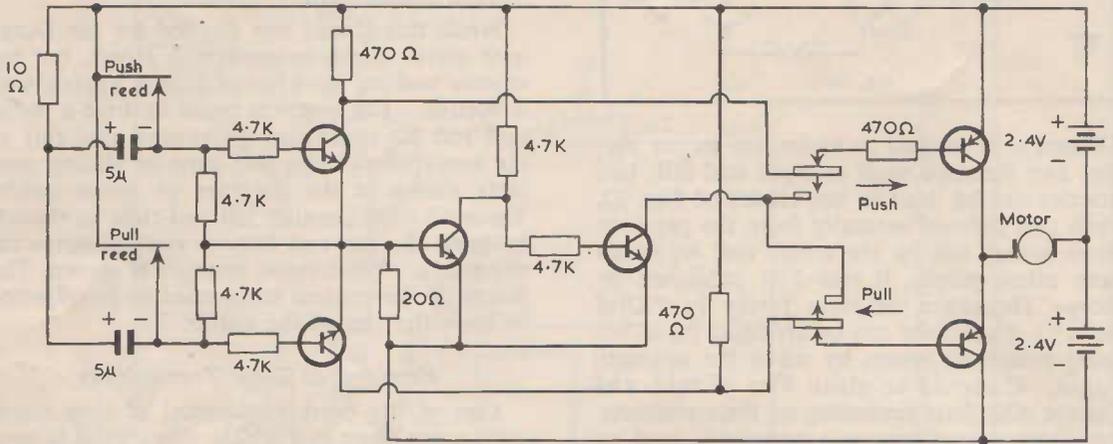
in "Grid Leaks". Use of this circuit is strictly limited to the home experimenter and publication does not imply the right for use by commercial manufacturers.

While this circuit was devised for the Dura-mite servo, it can be used with others, but for anyone making up a servo a little explanation is needed. The motor is made to drive a push-pull rod for operating the control and this at the same time drives two pairs of sliding contacts shown in the diagram as arrow heads. These all slide together left and right as shown, bridging the top and bottom contact strips respectively. The neutral position is shown. The length of the contact strips need to be adjusted to limit the run of the motor.

*Economical Tone Transmitters*

One of the most economical of tone transmitters is shown in Fig. 25. No crystal is used to stabilise the radio frequency, so this should be checked at intervals with a frequency meter. It ought really to be checked every time the transmitter is used after being moved, though it is not likely to vary much. The radio frequency section uses only one valve, a 3D6/1299A or a 3A4, either of which was obtainable quite cheaply at the time of writing. The audio frequency section uses two transistors and these can be low gain types. This part was introduced by Phil Kraft of the U.S.A. and the writer has constructed this separately and plugged it into different transmitters with satisfactory results.

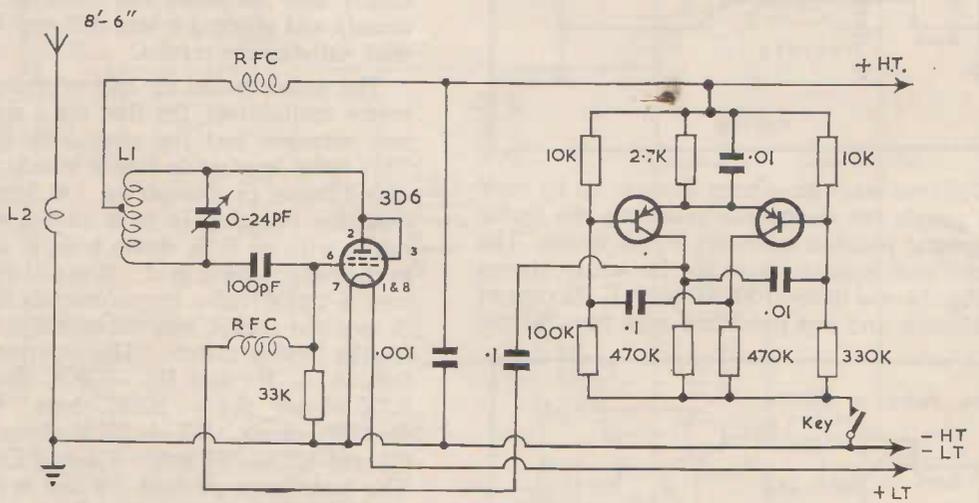
The writer made up two of these tone generator modulators, the first on a tag board for test purposes and the second for regular use. This latter was made just a bunch of components hanging on the wiring. A 3 pin plug was used for plugging in to a carrier wave transmitter with an R.F. choke built in and coupled to the output valve grid. It can also be plugged into a single valve transmitter as shown here. A two pin socket was connected in the wiring for the keying switch. The components are as follows:— R1 and R3 — 10K ohms. R2 — 2.7K ohms. R4 — 100K ohms. R5 and R6 — 470K ohms. R7 — 330K ohms, all 1/4 watt. C1 and C2 — .01 mfd. C3 and C4 — 1 mfd. The transistors advised for use are the OC71 and XB102, but the writer did have the modulator working very successfully with two low grade transistors purchased from the local dealers at 2/6d. each. It was felt, however, that these cheap ones would not be reliable, and failure would result in damage to the writer's model. In building this item as a "bunch" here is the procedure. One end of each resistor R4, R5, R6 and R7 are twisted



4 transistors, 2N229;

2, type 2N1038.

Fig. 24



L1: 10 turns 18 s.w.g. 1 1/2" long.  
L2: 1 turn insulated round centre of L1.

Fig. 25

together neatly and soldered to one tag of the keying socket. One end of R1, R2, R3 and C1 are soldered together and a piece of red flex also joined on. The free ends of R1, R4 and one end of C3 are soldered together, and the base lead of T1 joined on. R3, R7 and one end of C2 are soldered together and the base lead of T2 joined on. The free ends of R2 and C1, and the two transistor emitter leads are soldered together. The free ends of R5 and C2, the collector lead of T1 and one end of C4 are soldered together. The free ends of R6 and C3 and the collector lead of T2 are soldered together. The free end of the keying socket has a piece of black flex soldered on, and the free end of C4 has a piece of flex of a different colour soldered on. The other end of this flex is soldered to the centre pin of the plug. The other pieces of flex are soldered to the other pins of the plug. Generally, this flex need be no more than two or three inches long. A matching three pin socket is fixed on the transmitter panel with the centre leg connected to the valve grid through a radio frequency choke. Matching pieces of red and black flex are taken to the H.T. positive and negative respectively. Be very careful about this because connecting the leads the wrong way round

would destroy the transistors. The writer uses only 90 volts H.T. but this modulator will stand up to 135 volts.

The R.F. or oscillator section is quite simple, few parts being needed. The tuning coil L1 is made by winding 10 turns of 18 s.w.g. copper wire on a 1" diameter former, such as paxolin tube, and it is tapped in the centre. L2 is one turn of insulated wire round the middle of L1. The same sort of wire can be used in sleeving. The tuning condenser can be a 0.24 pf. compression type trimmer, or a Philips 30 pf. concentric trimmer. The 100 pf. grid condenser can be silver mica or ceramic. The 33K ohm grid leak need only be  $\frac{1}{2}$  watt. The .001 mfd. bypass condenser can be paper or mica insulation. The two R.F.C.'s. are made by winding a CH1 Neosid choke core full of 32 s.w.g. enamelled copper wire.

When completed the transmitter will need to be tuned. A Field Strength or Absorption wavemeter should be used. The meter is set to the middle of the Radio Control band and the transmitter tuned to give maximum reading on the meter, the meter being fixed as far from the transmitter as will give a useable reading. This may be less than a foot. The full aerial will need to be on the transmitter.

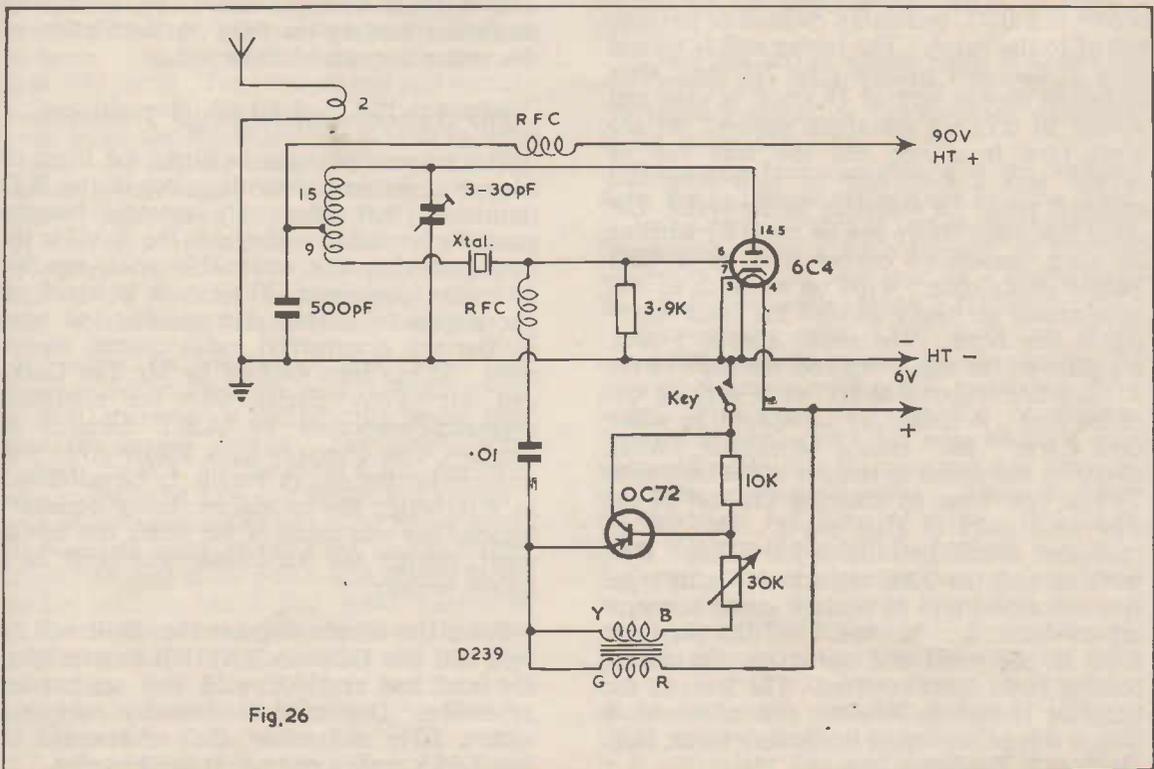


Fig. 26

Another economical transmitter, this time using a crystal for stabilising the radio frequency, is shown in Fig. 26. The valve used is cheap to buy and economical to run, the heater being fed from two cycle lamp batteries in series. A 90 volt dry battery can be used for H.T. the current being drawn then is 10 ma. The tone generator uses only one transistor, together with transformer and resistors, and operates from the L.T. supply. The crystal is an 'overtone' type between 26.96 and 27.28 megacycles per second. The valve section has been in use for many years on and off as a carrier wave transmitter and is therefore on a separate panel. The tone generator was built up as an addition for use with the Quetone receiver and was tested to a range, on the ground, of 300 yards which was considered sufficient. Models have many times been flown with less range. The valve section will be described first.

A panel layout is shown in Fig. 27 and the hole positions can be traced from this. Those for the crystal must be made to suit this item, some crystals being made to fit in holders and some to be soldered into the circuit. If a holder is used, a suitable hole must be cut, but otherwise all  $\frac{1}{8}$ " holes, except for the valve holder, can be fitted with eyelets to which components and wires can be soldered. The valve holder is a B7G, preferably ceramic or paxolin, bolted to the panel. The tuning coil is wound on a  $\frac{3}{4}$ " diameter paxolin tube  $2\frac{1}{4}$ " long. Bare or tinned copper wire of 18 s.w.g. is used and wound to take up the space shown. At the ninth turn from one end the wire can be twisted into a loop half an inch long and soldered, ready for soldering to the eyelet. The radio frequency choke can be made by winding 38 s.w.g. enamelled copper wire on a CH1 Neosid choke core. Wind on as much as will comfortably go neatly with all the turns touching in one layer. The choke core is 5 mm. diameter by 16 mm. long and the ends of the winding are soldered to the wires sticking out of the core. A choke can be bought, in which case a four "pie" should be chosen. When soldering remember to remove the enamel first. This is best done by stroking the end of the wire on a piece of glass paper. The 500 pf. condenser should be suitable for 500 volt D.C. working and the 3.9K resistor a  $\frac{1}{4}$  watt type. A compression type or postage stamp size tuning condenser can be used. All the parts are fixed to the panel and wired up, the wiring holding some items in place. The leads to the batteries should be flexible and of course a switch will be needed in the battery leads, H.T. plus and L.T. plus.

The tone generator has few components, the transistor being an OC72 or similar type, and the Ardente transformer type D239 is quite small. A small 5:1 intervalve transformer can be used instead if desired, but being larger would need a larger panel. The small transformer can be fixed to the panel with a turn of copper wire or bound with thread. Variable resistors usually have one hole for fixing. The transistor can be soldered in or a holder used, in which case a different hole for mounting will be required. The 10K resistor is  $\frac{1}{4}$  watt and the .01 condenser can be low voltage rating, though 150 volt will probably be more convenient. The R.F.C. is the same as before. A socket can be fitted for connection to the key.

When the set has been built it can be put in a suitable box and an aerial of eight feet long connected to it. It must then be tuned to the correct frequency. This is done by putting a milliammeter in the H.T. lead, one reading to about 20 or 30 m.a. being suitable. With the batteries connected up and switched on, the tuning condenser is operated until a dip in the current reading is found. At this point the circuit will be oscillating at the crystal overtone frequency. The current rises sharply each side of this point so tuning has to be done carefully. This adjustment can be more easily carried out with a Field Strength meter, by tuning for maximum reading on this. A description of this meter appears elsewhere.

#### *The Darkeagle All Transistor Transmitter*

This transmitter must be about the latest of its type at the time of writing since it uses R.F. transistors that have only recently become generally available. They are the XA131, the most powerful, at a reasonable price, suitable for such equipment. The circuit is based on one designed by Hans Schumacher and used in German commercial radio control equipment. It has been evolved by Mr. Jim Darke and Mr. Tony Eagles who are electronic engineers employed by A.E.I. Limited at Rugby. This company have kindly given permission for the circuit details to be published in this book, this procedure being necessary because use was made of the firm's test equipment, though the transmitter was built as a hobby venture.

From the circuit diagram Fig. 28 it will be seen that two Ediswan XA131 R.F. transistors are used, and at 35/0d. each they are not too expensive. Due to their economy compared with a valve transmitter, their cost would be saved in a season or two on the batteries.

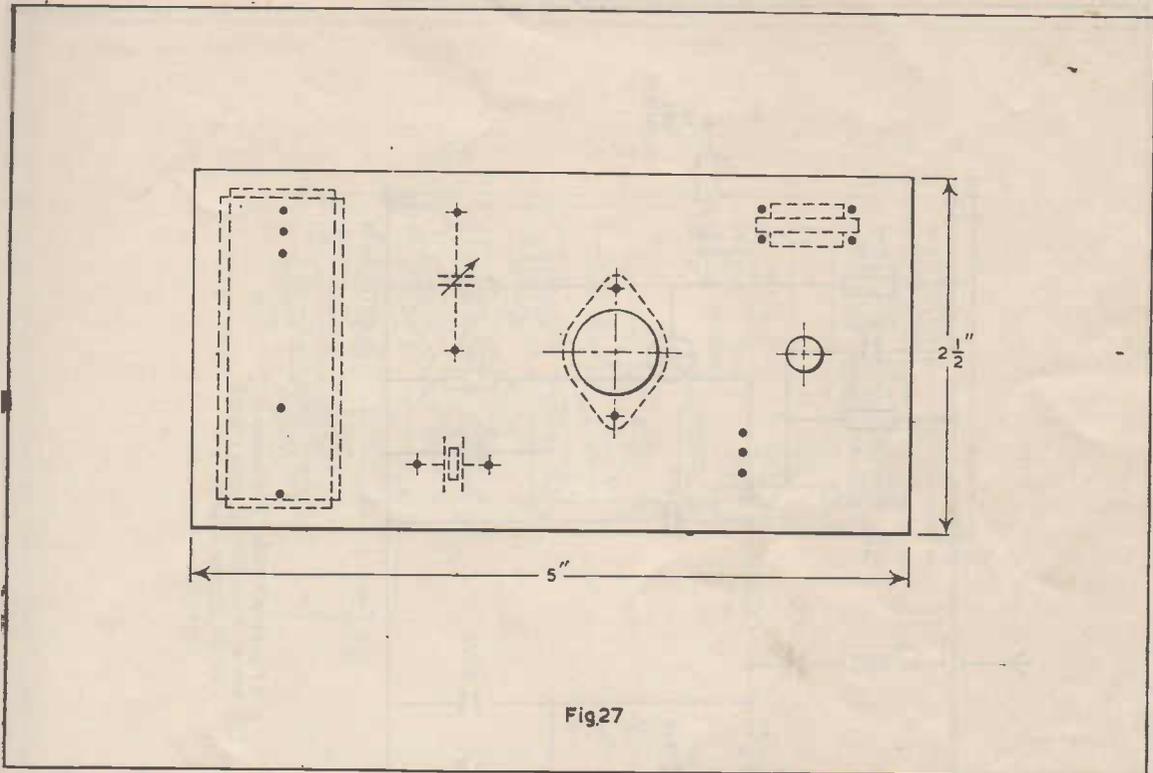


Fig.27

The power output is very impressive. With the writer's Quetone receiver housed in a model aeroplane fuselage, it was taken to the limit of the space available at the time, a distance of about 300 yards. The receiver was still operating properly with the fuselage half submerged in wet grass, and the transmitter was using only 9 volts. At this the transistors are not being worked beyond their normal ratings, though collector modulation is used. The transmitter was hand held with a 5 foot aerial and a 3 foot wire counterpoise. The receiver was tuned within a few yards of the transmitter with full aerial, so the range was considered very good.

It might be mentioned here that with collector modulation, the peak voltage across the P.A. transistor is theoretically about four times the supply voltage. The supply volts reaching the P.A. will be about 8, and the transistor rating is 30. Due to "production spread" some of these transistors will stand rather more, sometimes as much as twice the quoted rating. Anyone desiring more power and having facilities for selecting the higher grade transistors can increase the supply volts to 12 or 18. Some slight component value alteration will however be needed. For 12 volt supply resistor "a" should be increased to 2.2K ohms, For 18 volts "a" should be 2.7K ohms, "b" 4.7K ohms, "c" 12K ohms and the zener diode D should

be OAZ207. These identifications are shown on the circuit diagram but not on the panel layout.

A full size layout of the panel is shown in Fig. 29 but the aerial loading coil L4 and the 2K variable resistance are mounted elsewhere in the transmitter box.

The audio frequency choke is the bulkiest item, but at present nothing can be done about it. Two have been tried in turn to cover different frequencies. For 1 Kc/s upward an English Electric "C" core was used in a single loop, the catalogue number being Z371030.

The winding was 1,000 turns of .0076 enamelled copper wire and this gave an inductance of .6 henries with a D.C. resistance of 32 ohms. For tones down to 500 or perhaps 300 c/s a winding of 1,000 turns of .0076 wire was used again, but the core was two loops of the same catalogue number. There is room on the panel for this size choke. For lower tones a larger choke will be needed.

Construction of a transmitter on these lines is very simple. The panel is marked out and small holes drilled at the spots. In the original, Harwin pins were used and these are just right for the job if you have them. However, a cheap and easily obtained substitute is brass rivets as used in shoe repairs. No. 17 x 3/8 is a convenient size and these can be tapped



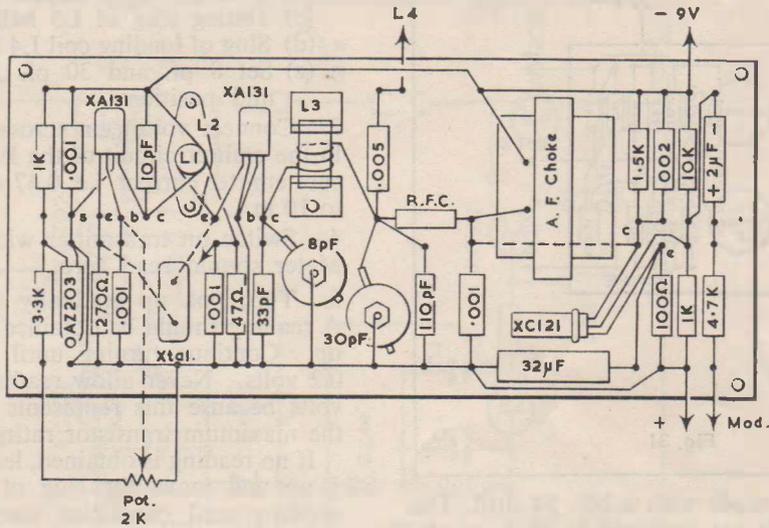


Fig. 29

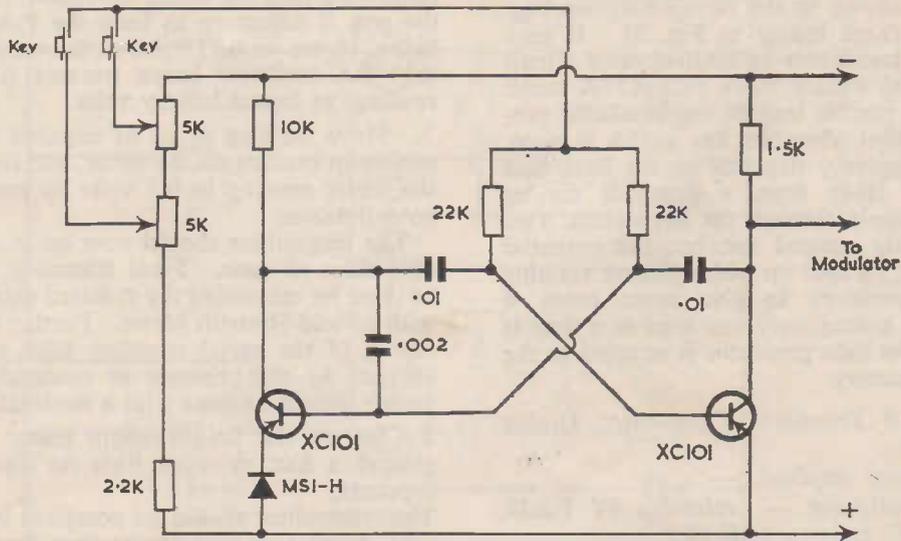
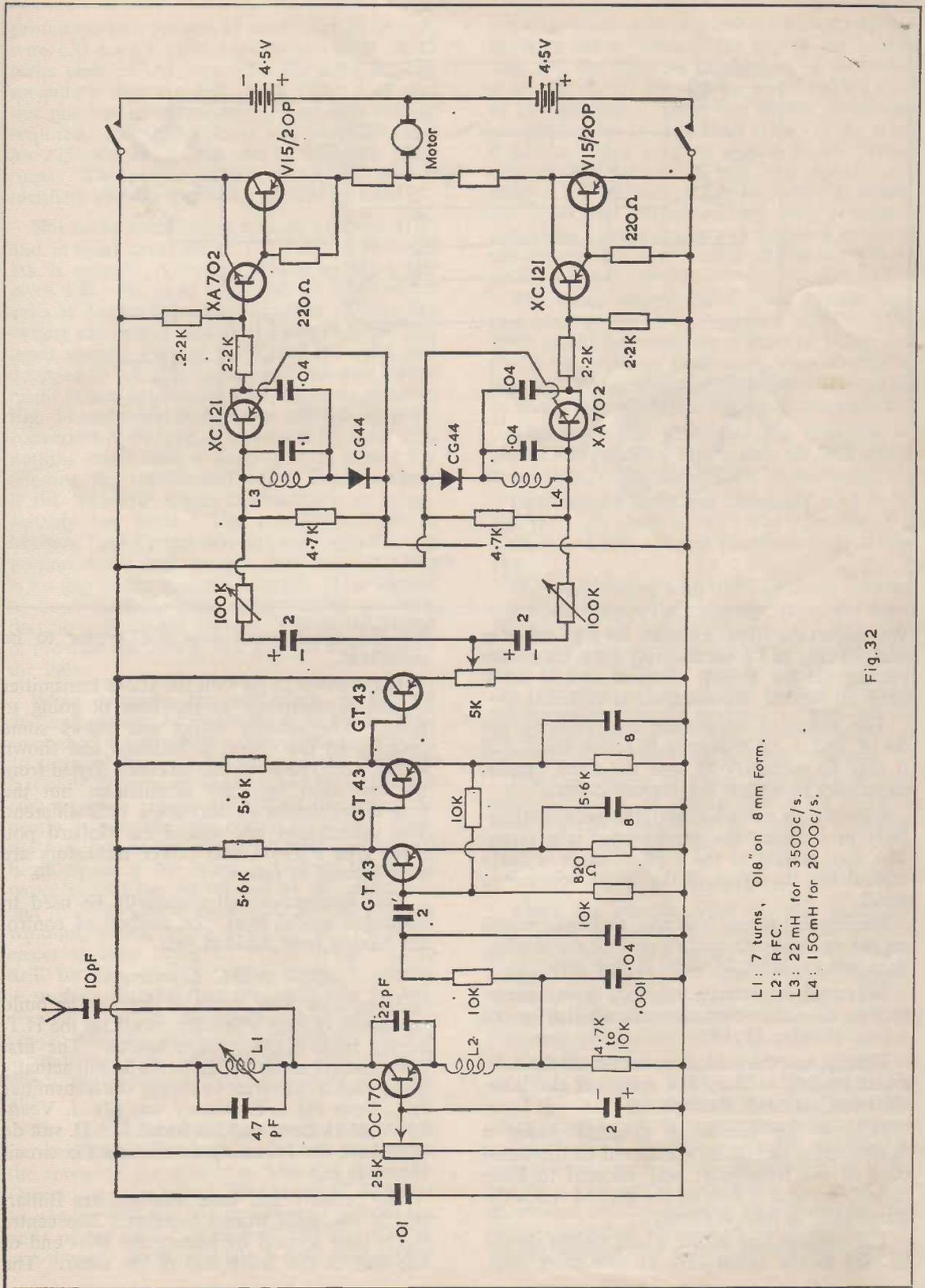


Fig.30





L1: 7 turns, 018" on 8mm Form.  
 L2: RFC.  
 L3: 22mH for 3500c/s.  
 L4: 150mH for 2000c/s.

Fig. 32

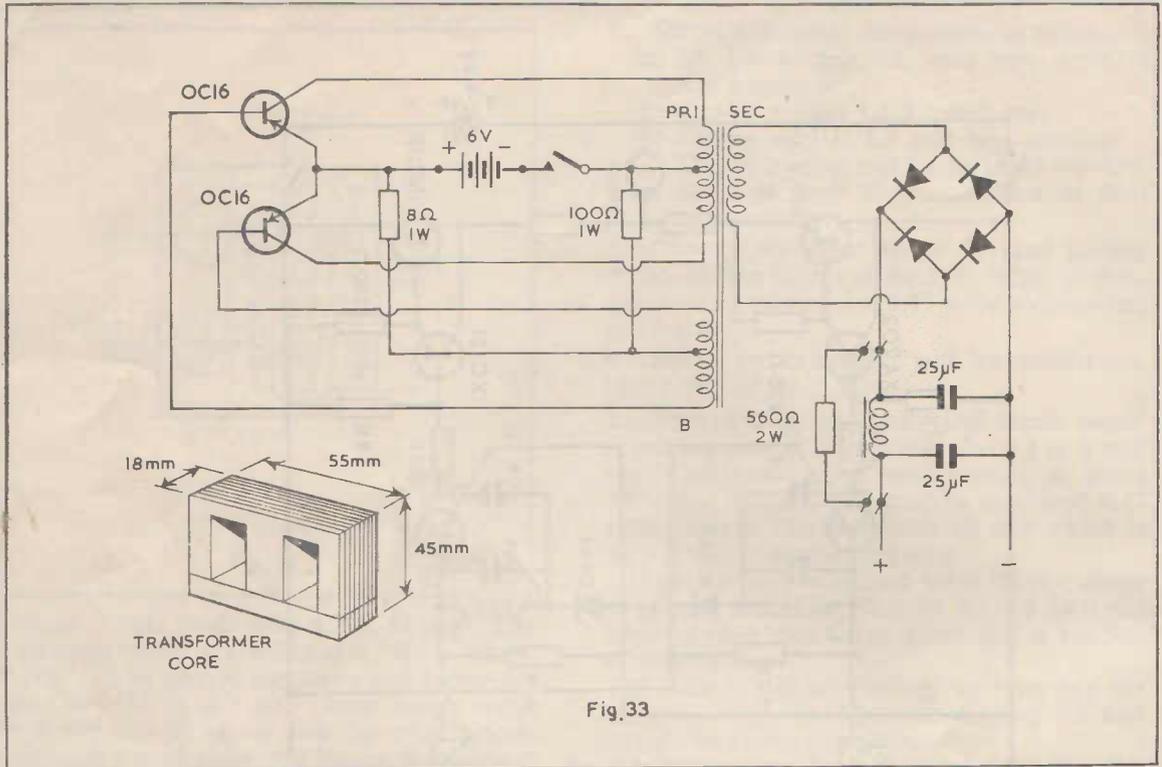


Fig. 33

9. Adjust the 30 pf. trimmer, the 8 pf. trimmer and the slug of L4 successively for a maximum reading on the F.S.M. Repeat several times until no further improvement is obtained.

The range of adjustment available on the 30 pf. and 8 pf. trimmers is rather small and it may be necessary to alter the fixed parallel capacitors to obtain the highest output.

L3 may be moved slightly to help, particularly in bringing the pf. trimmer into range. The final setting of the 8 pf. trimmer is fairly critical but the effect of the 30 pf. trimmer is small.

During this tuning it is wise to keep a watch on the voltmeter to make sure that the reading does not exceed 0.47 volts at any time.

When all is correctly aligned, the voltmeter reading should remain constant whether or not a tone is being keyed.

Finally, use the potentiometer to set the voltmeter reading to about 0.4 volts and check the above adjustments through again.

Note:— for maximum radiated power a flexible wire should be connected to the metal case of the transmitter and allowed to hang to within about a foot of the ground when the transmitter is held normally.

The positive line of the whole circuit should be tied to the metal case at one point only,

but the exact point does not appear to be important.

The receiver to go with the above transmitter is still experimental at the time of going to press. The scheme works and shows some promise so the circuit is included and shown in Fig. 32. The front end has been copied from the one used by Hans Schumacher but the tone discriminator circuits are a little different. The inductances are wound on Mullard pot. cores type FX1011 and power transistors are used instead of relays.

This equipment will eventually be used to control a model boat, the method of control not having been decided yet.

#### D.C. to D.C. Converters

Transistors have made it possible to build converters of high efficiency, to obtain the H.T. supply from a low voltage source. The first radio control modeller the writer found actually using such a converter to supply the transmitter H.T. from the L.T. battery was Mr. J. Veenhoven of Holland and his friend Mr. D. van de Wall gave the following details and the circuit shown in Fig. 33.

The primary and base windings are Bifilar, that is two coils wound together. The centre tap is then formed by joining the start end of one coil to the finish end of the other. The

primary is two coils of 35 turns each of .9 mm. wire (20 s.w.g.) The base is two coils of 15 turns each of .35 mm. wire (29 s.w.g.). The secondary uses .16 mm. wire (38 s.w.g.) and the number of turns depends on the voltage required. For 170 volts it will be 1,230 turns for 225 volts 1,620 turns and for 250 volts 1,800 turns. The output current is 45 ma. Silicon rectifiers such as the SJ301 should be used.

Not many transmitters require so much H.T. and in most cases about 100 volts at 10 to 15 ma. is enough. A converter built by the writer gives 100 volts at 15 ma., with an input of 6.5 volts at 4 amps from a 'nife' battery. With a dry battery the output was 85 volts at 12.5 ma. The input current was .34 amps and the volts had dropped to 5.7. The battery was not new so the result is not optimistic. The circuit is given in Fig. 34 and while it is not as efficient as some converters of its type, it was made by hand with nothing more than a hand drill in a vice for winding the transformer coil. The transistor is the V15/10P which is obtainable at a reasonably low price. The transformer uses a Mullard LA1 Ferroxcube pot. core with the ring ground down with emery cloth so that there is no gap in the magnetic circuit. This should be done carefully using a micrometer to check that no hollows are formed. Check the height of the ring and core with a straight edge against the light.

When winding, the secondary is put on first and consists of 700 turns of 38 s.w.g. (.006) enamelled copper wire. The primary is next, 40 turns of 28 s.w.g. (.0148) and the feedback last with 30 turns of 30 s.w.g. (.0124) enamelled copper wire. These should all be wound as neatly as possible, like cotton on a reel. After the first few layers of the thinnest wire it will begin to get a bit rough. A layer of waxed paper should be put on top of the secondary and this will give a good start for the primary winding, which, being thicker, will be a bit easier to keep straight. When using a hand drill for the winding, some form of counter is useful. Failing that the turns can be calculated from the gearing of the handle to the chuck, and the handle turns counted for the secondary. For the feedback and primary windings the turns should be counted individually.

The bobbin is not very strong, so it should be supported between two washers to prevent the spread of the wire from breaking the walls. One washer can have a hole about  $\frac{1}{8}$ " diameter to line up with the gap in one wall to hold the ends of the wires. The final end can also be put through the hole while a strip of gummed

paper is stuck over the bobbin to hold all the turns in place. Due to the gap in the bobbin wall and the different thicknesses of the wires, it is easy to tell the starting and finishing ends of the windings. These are shown in the diagram assuming the windings are all in the same direction. If a winding should be the wrong way round, the circuit will not operate correctly. For instance, if the secondary is wrong, the input and output will be only  $\frac{1}{4}$  what it should be. If the primary or feedback is wrong the circuit will not operate and there will be an input but no output.

The diode should be a good silicon type, that used by the writer being an SJ201A. The 201B could be used, the difference being that the B has wires at both ends for soldering or bolting. When soldering it is necessary to take as much care as when soldering transistors.

The diode and transistor are mounted on aluminium brackets, but as they are well within their ratings, no cooling fin is necessary.

Open circuit volts are about 120 and at 20 ma. the volts drop to 90. The operating frequency is 1,000 c/s and the ripple is less than  $1\frac{1}{2}\%$ .

If experimenting with this circuit for different input and output the resistors across the input can be replaced with a variable of 1,000 ohms and a 500 ohm variable can be put between the base of the transistor and the feedback winding. Different values of the condenser across the secondary should be tried. These should all be adjusted for the maximum efficiency, or they can be varied to give greater output.

For the design of these converters, a very useful booklet is obtainable from Messrs. Standard Telephones and Cables, Limited, Footscray, Sidcup, Kent.

### *Tone Generators*

There are various types of tone generator, about the most widely used for radio control purposes being the multi-vibrator using two transistors. Perhaps it should be pointed out though, that another type using a tuned inductance is gaining popularity and for certain purposes will replace most other forms.

A multi-vibrator suitable for most single tone receivers is shown in Fig. 35. The writer has used this particular circuit, built on one small piece of tag board, for some time with complete satisfaction. It feeds into a valve amplifier to modulate the output stage of a two valve transmitter. This transmitter being of the crystal controlled oscillator-power amplifier type. The tone is switched on and off by a relay in the battery supply, but a push-button can be used

just as well if desired. A higher tone can be obtained simply by using condensers of lower value than the .1 mfd. shown.

A variation on this is shown in Fig. 30 in which the tone can be tuned over a wide range. Altering the condensers will change the range over which it can be varied. The on/off switch for the tone is in the potentiometer lead. The silicon diode in the emitter lead of one transistor is to prevent oscillation when the tone is off.

Another type of tone generator uses one transistor and a small transformer. The Ardente D239 was found to operate satisfactorily and the connections are given for this. The generator has been used in a transmitter described elsewhere.

Other tone generators are shown in other equipment.

*Pulse Proportional Control*

The writer's pet control is that usually known as proportional. Different people have different definitions for this type of control but, in the writer's case, the amount of turn of the model is proportional to the amount a knob on the transmitter is turned and with the equipment used there is little difference with or without the engine. In other cases the control surface on the model moves proportionally to the transmitter control. This will, of course, give a proportional manoeuvre except in the case of a rudder which may or may not have the slipstream over it.

The method of obtaining this proportional control has, for some years, been to pulse the signal. Take, for instance, a rudder which is held to the left in some way if there is no signal. Then when a signal is transmitted the rudder is pulled to the right. If the signal is pulsed evenly on and off, the rudder will be pulled evenly right and left. The average position will be in the middle, steering the model in a straight line. If a little right turn is wanted, the signal is held on a bit more than off, and for a little left turn the signal is held more off than on. The actual speed of pulsing is not important though at low speeds the model may wag a little from side to side when set for straight. The speed of pulsing can be increased by reducing the value of the 4 mfd. condensers to 2 mfd. or less.

To pulse the signal the required amount, a multi-vibrator is used operating a relay to switch the signal on and off. The one used successfully for some years is shown in the diagram of Fig. 36. The on/off proportion is controlled by the 50K ohm potentiometer and this must have a definite stop to limit its movement to about 90 degrees each side of the

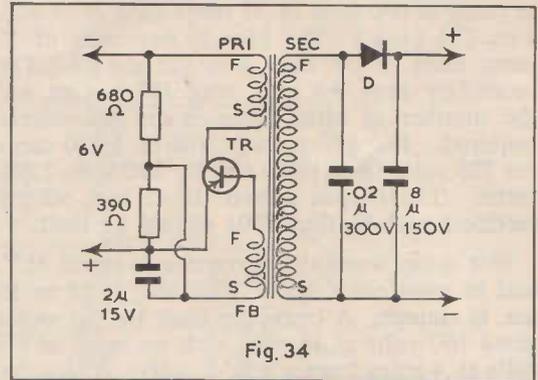


Fig. 34

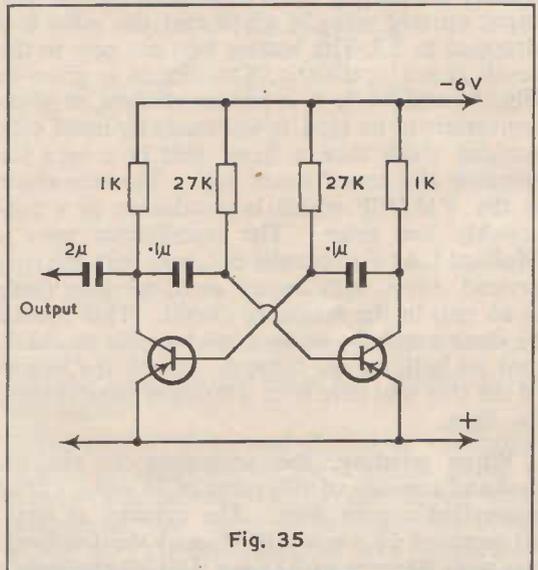


Fig. 35

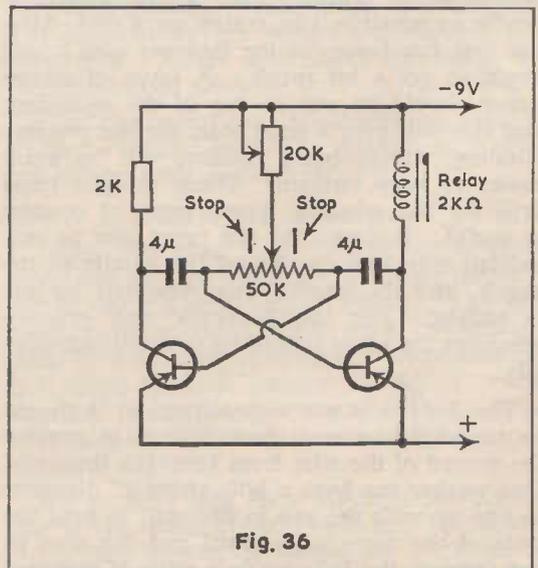


Fig. 36

middle. This is necessary to leave some of the resistance at each end in circuit. The 20K ohm potentiometer varies the speed of the pulsing. A relay of 1,000 ohms can be used, in which case the 2K resistor ought to be reduced to 1K. If a good enough relay is used, the voltage can be reduced. If no change in pulse speed is required the 20K pot. can be omitted. The transistor type is not important and usually a cheap variety will do. Current consumption is quite low, so pen light cells will last a long time.

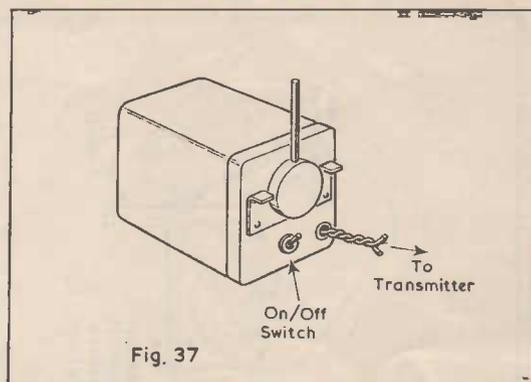
The 50K potentiometer can be fitted in the lid of a tin with the knob held with a long screw as shown in Fig. 37. The screw can be used as a lever and two stops fixed to prevent it rotating more than half a turn. An on/off switch can also be mounted in the lid and the other components mounted on a tag board inside. The battery can also be inside, leaving just two wires coming out to go to the transmitter from the contacts on the relay.

This pulser can be used to switch the H.T. for a carrier wave transmitter, or the tone for a tone modulated transmitter. Care will be needed, however, with the connections which will depend on the relay. It is advisable to have the relay contacts completely insulated from the box. In some relays the metal frame is also a contact connection and therefore it should not be connected to the box, or you may find the box at H.T. voltage. This would be shocking! If the keying socket was in the H.T. negative lead it would be all right, but you never know how the pulser will be used at some later date.

#### *Actuator for Proportional Control*

With proportional control by the pulse method, the battery is in use all the time, so this design of actuator was produced to be as efficient as possible to reduce battery drain. Originally it had a centre tapped coil to operate from both contacts of a relay, but when a transistor replaced the relay it was equivalent to removing one of the relay contacts. It is possible to devise a circuit using transistors to give switching equivalent to the two relay contacts, but this simpler scheme was tried and found to be just as good in practice.

All the dimensions given are to suit a permanent magnet of  $\frac{3}{4}$ " diameter by  $\frac{3}{32}$ " thick, polarised across the diameter. These are readily available. Other sizes have been used with exactly the same type of construction. Parts are shown in Fig 38 and two will be required of the pole piece and coil cheek, and one of each of the other parts. The assembled parts are shown in Fig. 39.



The magnets have a hole in the middle, which needs to be filled with a piece of brass. This is then drilled and the shaft soldered in. It is essential that the shaft and periphery of the magnet are concentric. If the assembly is not true, it should be rotated on the shaft and the magnet lightly ground true. The diameter of the magnet is then measured and the end piece turned to suit. It is best rotated on the shaft bearing hole for this. The pole pieces can be bent on a former  $\frac{3}{4}$ " diameter or a little less and should be made as accurate as possible. There may be high spots, but these can be filed down after trial assembly. All filings or other magnetic dust must be wiped off, plastercine being suitable for this since the magnet will hold iron dust better than cloth dusters. The lever should be soldered on in line with the magnet poles. If the magnet shaft is put through the end piece and the pole pieces and core put on, the magnet will line up with the pole pieces. The lever can then be lined up with these. A piece of thin copper wire is wrapped around the shaft between the lever and the end piece to take up end movement.

The coil can be wound on the core. First put about two layers of paper on the core and then put on the cheeks. These can be held in place with screws and large washers. One screw can be extended to be held in the chuck of a hand drill, this being held in a vice for winding on the wire. If you have the use of a coil winder, so much the easier. Use 36 s.w.g. enamelled copper wire and fill the bobbin. The actual number of turns is not important. The actuator battery will be about three to six volts according to the power required. The current should not exceed 200 ma. for the size of wire used and this can be handled by many small transistors, though they are no cheaper than the power transistor used in the McQue relayless receiver described elsewhere.



The method of using this actuator is shown in Fig. 40. If the lever is held at right angles to the pole pieces, slight movement to one side or the other will allow the permanent magnet fixed to try to rotate in that direction. With a spring fixed to pull the lever just past the centre, it will rotate past the spring anchor point P and begin to stretch the spring in the direction of A as shown for the signal off condition. With a signal on, current will flow through the coil and cause the magnet to rotate in the direction of B, pulling against the spring. If the current goes the wrong way through the coil, the magnet will rotate in the other direction, but this is easily altered. All that is needed is to turn the lever halfway round and put the spring in the other end. The spring is made from steel wire .01" diameter, a single strand from a cycle brake cable will do and ten or twelve turns are wound on a 3/16" former. A square hook is bent on one end to go through the lever and a round hook at right angles at the other end to go on a pin. The point P is found by trial with the whole equipment working. The spring must not be pulled too tight and it must not be anchored too much to one side. The position is fairly critical but quite easily found, the lever jumping from one side to the other very readily as the signal is switched on and off. Some sort of screw adjustment is advisable in the rod between the lever and the rudder.

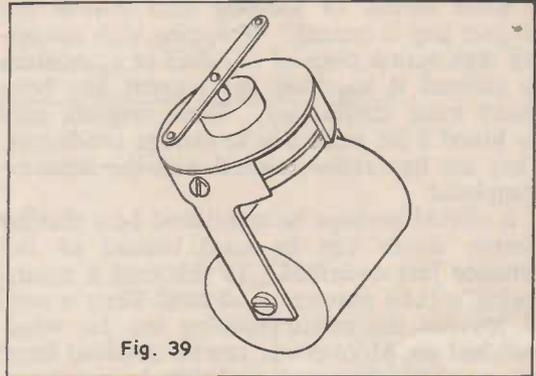


Fig. 39

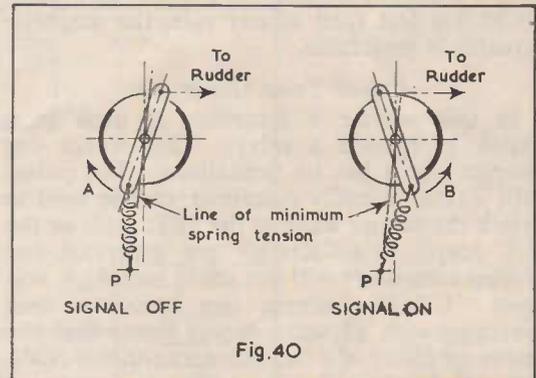


Fig. 40

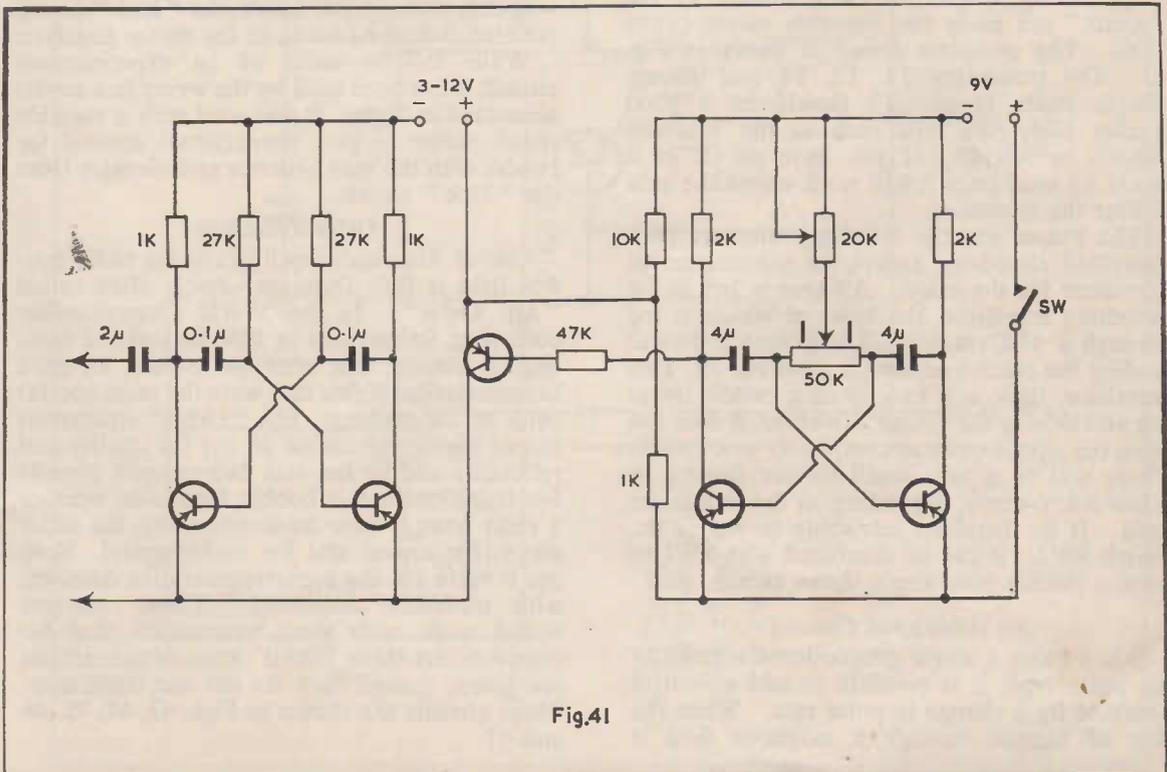


Fig. 41

Some means of keeping dust out of the magnet gap is needed. Wrapping with insulating tape with a piece of celluloid or aluminium to prevent it touching the magnet has been found quite satisfactory. Some magnets may be found a bit weak due to storage conditions. They are best re-magnetised with the actuator completed.

It should perhaps be mentioned here that an electric motor can be used instead of the actuator just described. In this case a return spring will be required, and most likely a stop to prevent the motor rotating too far when switched on. More power can be obtained from a motor, which would probably be necessary with a boat, but for steering a model aeroplane, up to five feet span at any rate, the magnetic actuator is preferable.

#### Pulsed Tone Generator

In this scheme a transistor is used as a switch to replace a relay. This works out cheaper but it has its limitations. The pulser with a relay, already described, can be used to switch the carrier wave in the H.T. lead, or the H.T. supply to a "Kraft" tone generator, but present transistors will not stand such high voltages. Using a simple two transistor tone generator with 12 volts, it was found that the power amplifier of a two valve transmitter could be modulated without an intervening valve stage. This transmitter was similar to the "Kraft" but using two separate valves (Type 3D6). The complete circuit is shown in Fig. 41. The transistors T1, T2, T4, and T5 are simple audio types. T3 should be a good quality high gain type such as the Ediswan XB103 or XB105. If you have an OC76 it could be tried since it will work unless the gain is near the minimum.

The Pulser and the tone generator are both described elsewhere, except for substitution of a resistor for the relay. All that is left is the switching transistor, the base of which is fed through a 47K resistor. The potential divider feeding the emitter ensures a good cut-off. This transistor, then, acts exactly as a switch, opening and closing the circuit. However, it does not open the circuit quite as completely as a switch. There will be a very small current flowing of a few micro-amps, depending on the transistors used. It is, therefore, advisable to put in the switch SW2. It can be combined with SW1 to form a double pole single throw switch.

#### An Additional Control

When using a single proportional control of the pulse type, it is possible to add a control operated by a change in pulse rate. When the flow of current through a magnetic field is

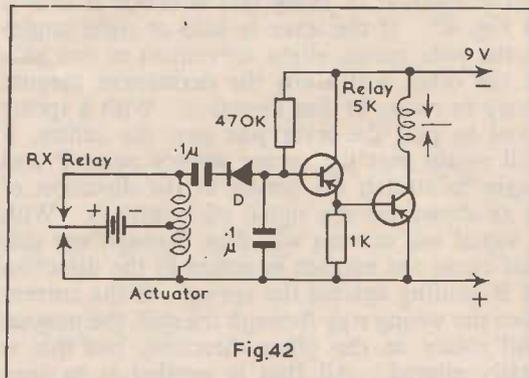


Fig.42

stopped suddenly a voltage of reverse polarity is induced in the winding. This "kick" can be applied to the base of a transistor to make it conduct. A simple circuit for this is shown in Fig. 42 and this gave good results with popular cheap transistors. A germanium diode was used as D, and a good sensitive relay was used. Different relays could be used with different voltages. With the .1 mfd. condensers the relay would follow pulse rates of about 11 per second or less. Larger capacity would cause the relay to hold on at high pulse rates, but stay open at slow ones.

A magnetic actuator is shown, but there is no reason why the leads should not be used across an electric motor. If pulses are sent one way only through the motor, the "kick" circuit positive should be taken to the motor negative.

While this is more of an experimenters circuit, it has been used by the writer in a model aeroplane in flight. It was used with a variable speed pulser to give proportional control for rudder with the man actuator and elevator from the "kick" circuit.

#### Orbit Receivers

One of America's top flyers in the radio control field is Bob Dunham who is often called "Mr. Orbit". In the World Championship contest in Switzerland in 1960 he suffered from engine trouble, but after the contest he gave demonstration flights that were the most spectacular of the meeting. His "Orbit" equipment has as high a reputation as any for quality and reliability and he has sent two receiver circuits for inclusion in this book. One is to operate a relay from a tone transmitter and the other one is for a reed unit for multi-control. Both use a valve for the super-regenerative detector, with transistor amplifiers. These receivers would work with most transmitters, but for completeness three "Orbit" transmitter circuits are given, though they do not use transistors. These circuits are shown in Figs. 43, 44, 45, 46 and 47.

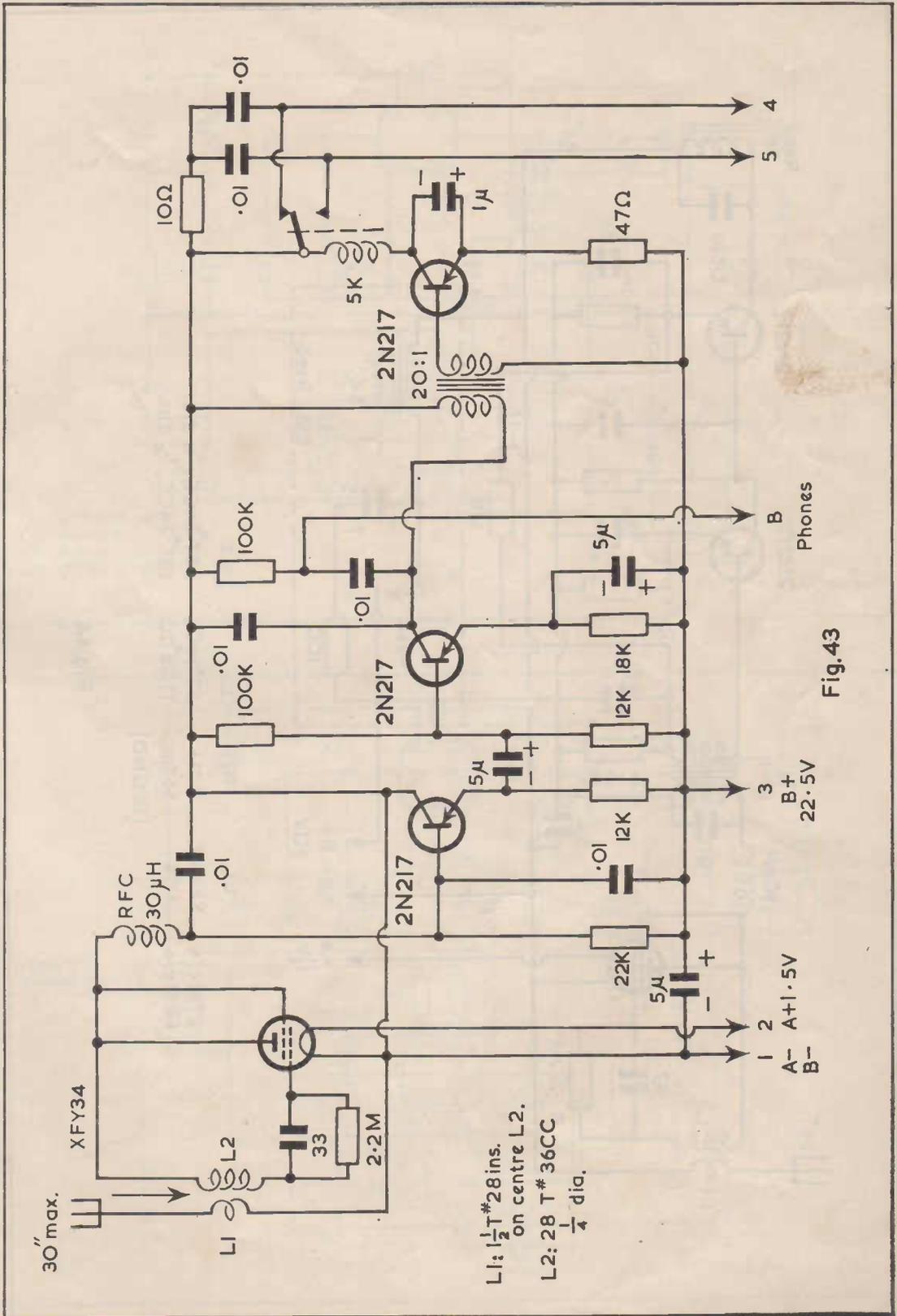


Fig. 43



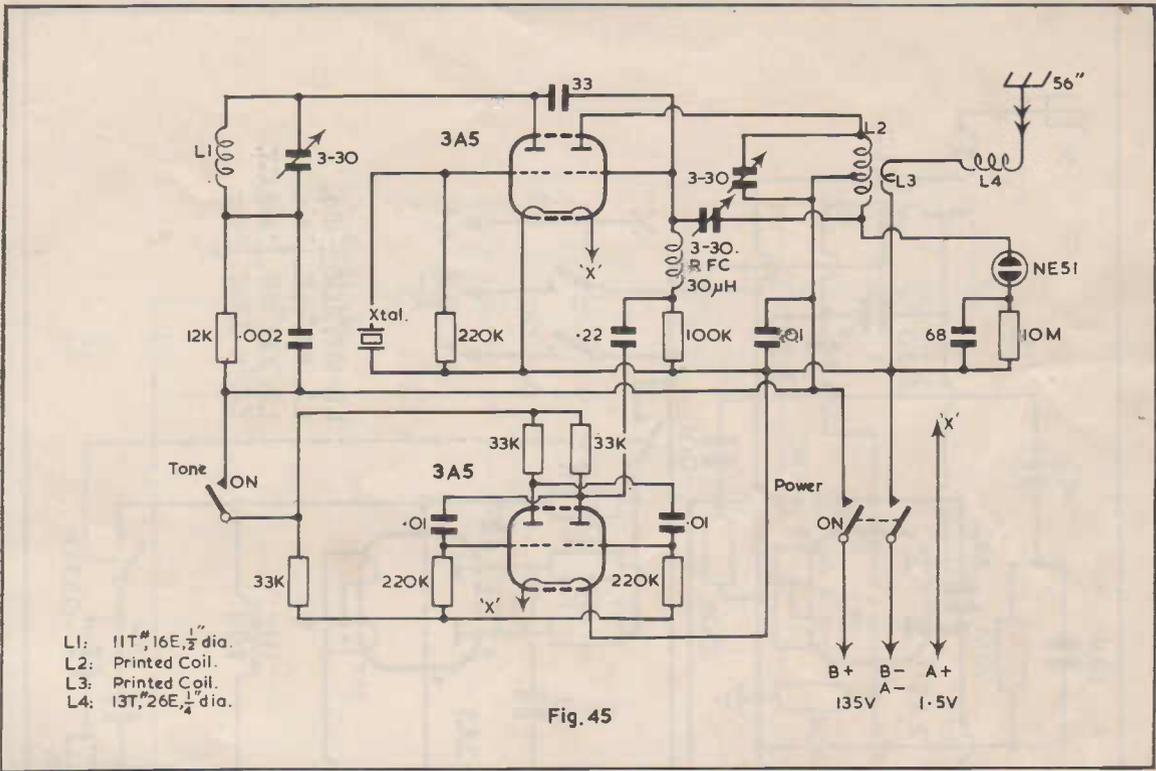


Fig. 45

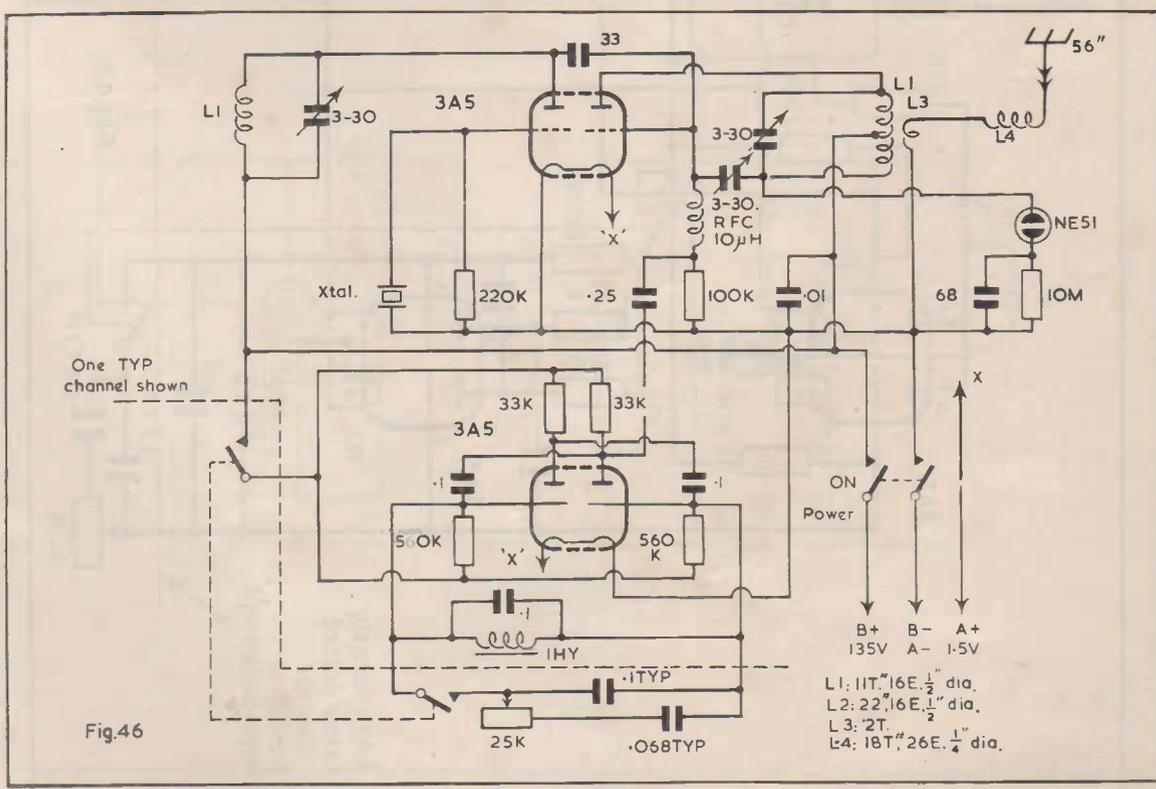
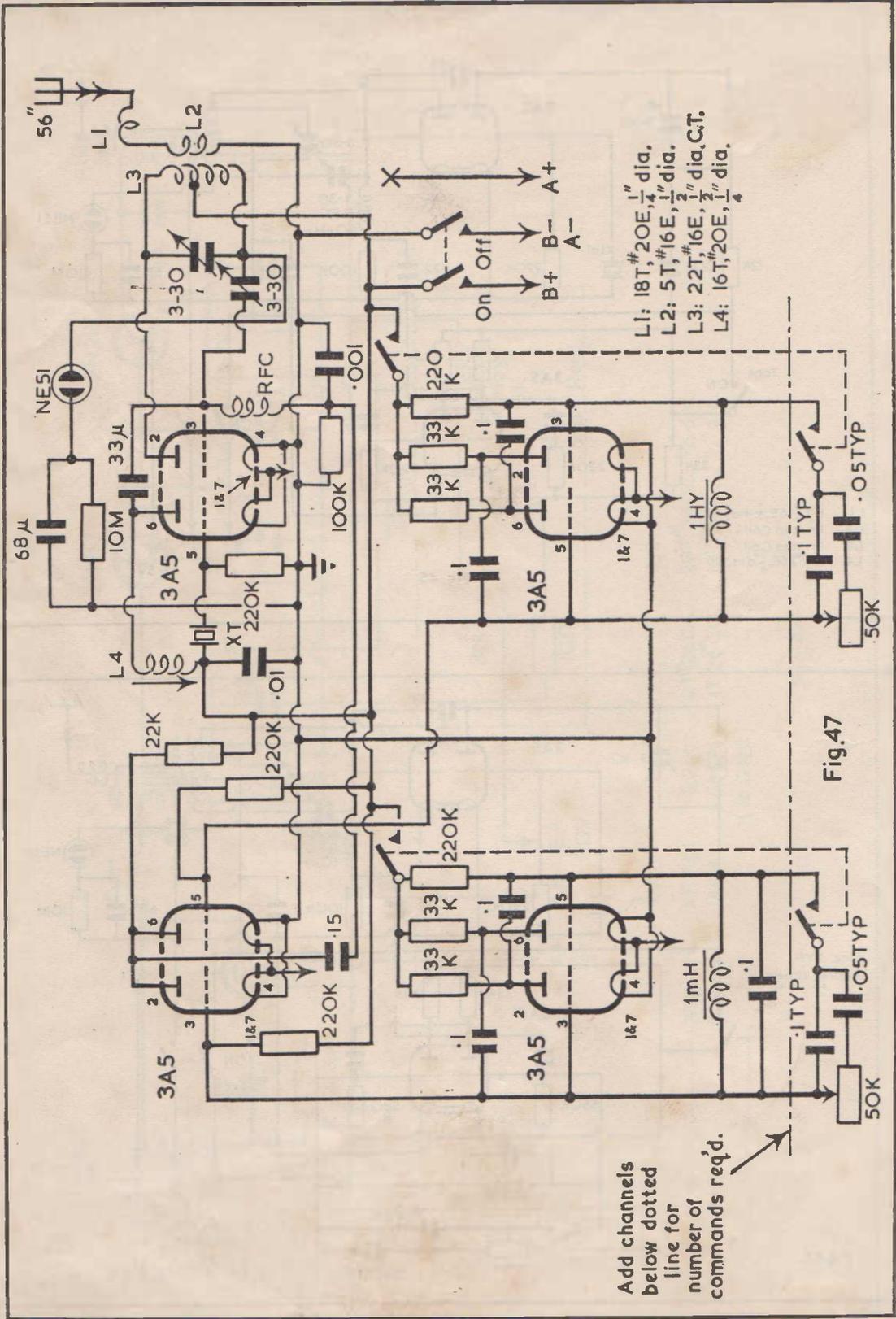


Fig. 46



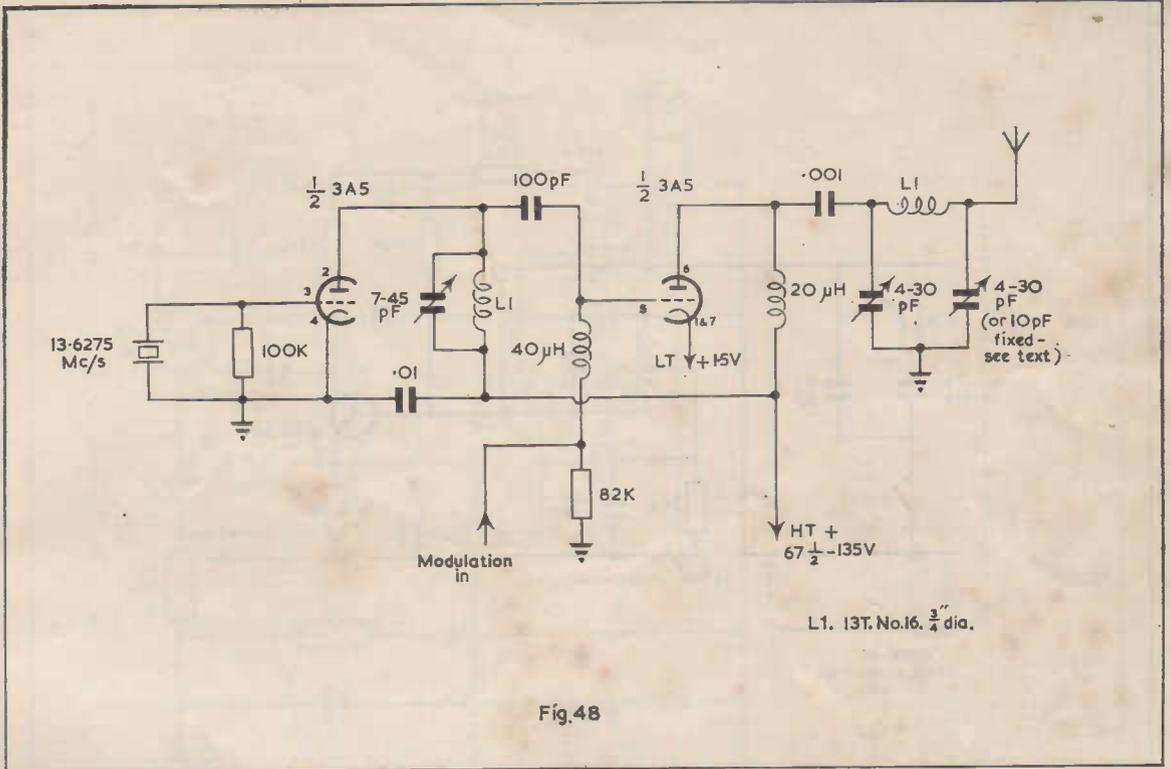


Fig.48

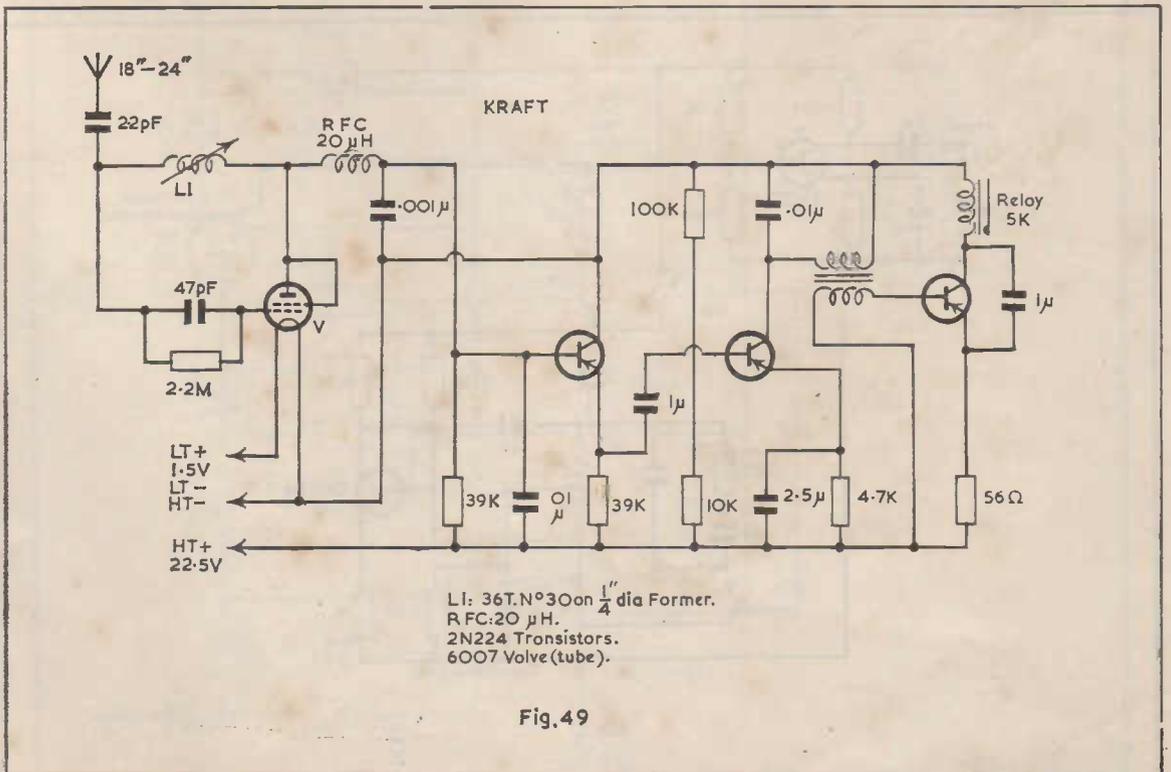


Fig.49

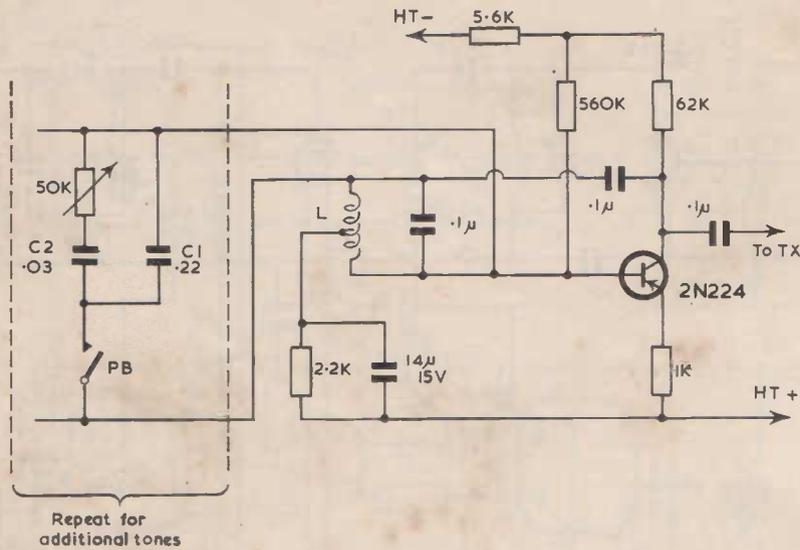


Fig.50

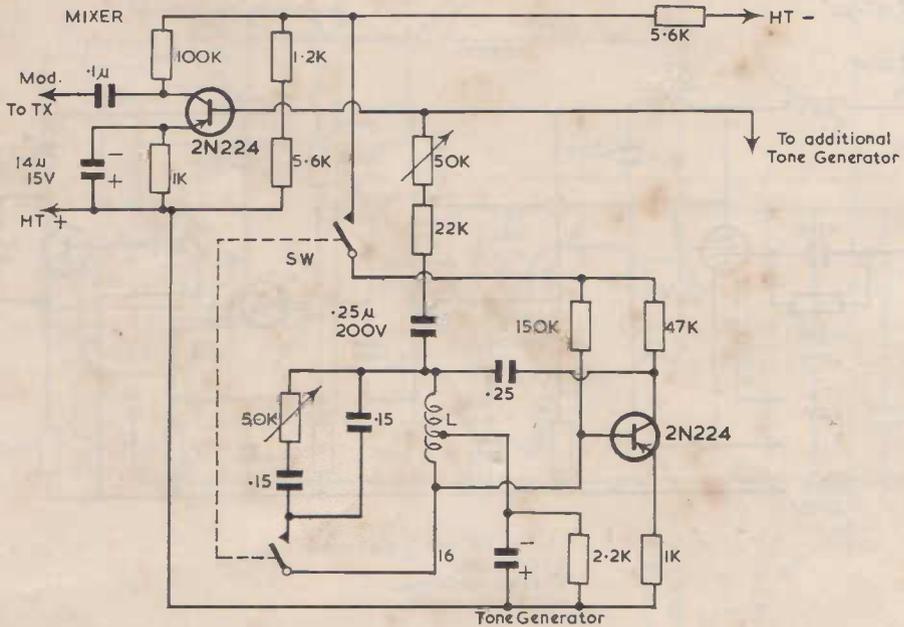
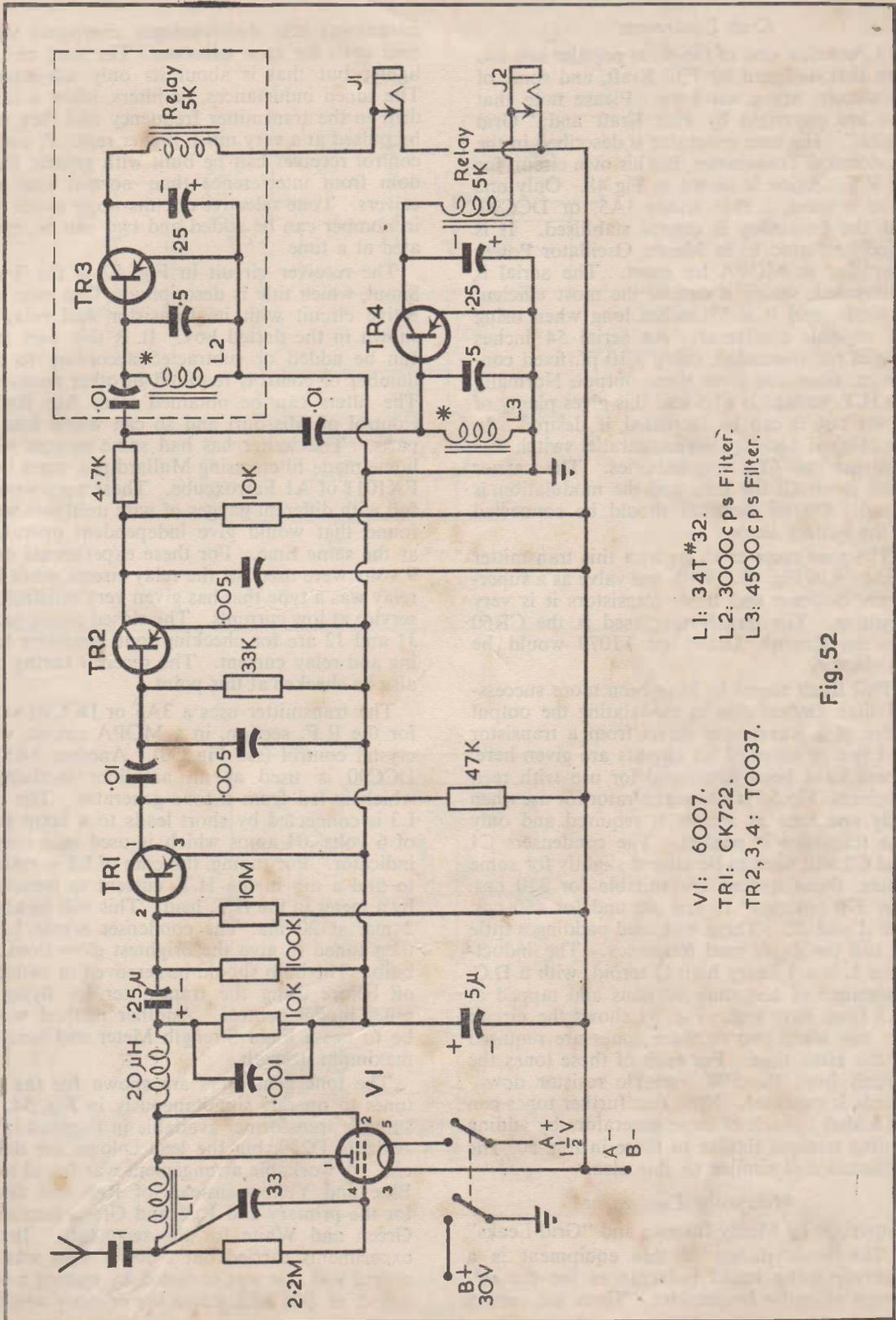


Fig.51



- VI: 6007.
- TR1: CK722.
- TR2,3,4: T0037.
- L1: 34T #32.
- L2: 3000cps Filter.
- L3: 4500cps Filter.

Fig. 52

### *Kraft Equipment*

In America, one of the most popular sets has been that designed by Phil Kraft, and some of his circuits are given here. Please note that they are copyright by Phil Kraft and "Grid Leaks". His tone generator is described in the Economical Transmitter, but his own circuit for the R.F. section is shown in Fig 48. Only one valve is used, a twin triode 3A5, or DCC90, and the frequency is crystal stabilised. It is usually referred to as Master Oscillator Power Amplifier or MOPA for short. The aerial is pi coupled, which is one of the most efficient methods, and it is 37 inches long when using the variable condenser. An aerial 54 inches long is recommended, using a 10 pf. fixed condenser, since this gives more output. Normally the H.T. voltage is 67.5 and this gives plenty of power but it can be increased if desired. In the original design, a series/parallel switch was used for two 67.5 volt batteries. The carrier wave is on all the time and the modulation is keyed. On/off switches should be connected in the battery leads.

The tone receiver to go with this transmitter is shown in Fig. 49. With one valve as a super-regen. detector and three transistors it is very sensitive. The transformer used is the CR60 but the English D1001 or T1079 would be satisfactory.

Phil Kraft seems to have been more successful than anyone else in modulating the output valve of a transmitter direct from a transistor and two or more of his circuits are given here. These have been developed for use with reed receivers. Fig. 50 is a tone generator for use when only one tone at a time is required and only one transistor is needed. The condensers C1 and C2 will need to be altered slightly for some tones, those quoted are suitable for 310 cps. For 370 cps. use .15 and .02 and for 460 cps. use .1 and .02. These will need padding a little to suit the exact reed frequency. The inductance L is a 1 henry high Q toroid, with a D.C. resistance of less than 90 ohms and tapped at 1/3 from base end. Fig. 51 shows the circuit for use when two or three tones are required at the same time. For each of these tones the circuit from the 50K variable resistor downwards is repeated. Note that further tones can be added to each of these generators by adding tuning sections similar to those in Fig. 50. The inductance is similar to this also.

### *Marcytone Equipment*

Copyright by Marcy Inkman and "Grid Leaks"

The basic design of this equipment is a receiver using tuned inductances for the selection of audio frequencies. There are certain

advantages and disadvantages compared with reed units for tone selection. The reed unit is lighter but that is about its only advantage. The tuned inductances, or filters, allow a little drift in the transmitter frequency and they can be pulsed at a very much higher rate. A single control receiver can be built with greater freedom from interference than normal tone receivers. Tone selective circuits up to about ten in number can be added and two can be operated at a time.

The receiver circuit in Fig. 52 is the Twin Simul, which title is descriptive. One tone selective circuit with its transistor and relay is shown in the dotted box. It is this part that can be added or subtracted according to the number of controls required in other receivers. The filters can be obtained from Ace Radio Control of Missouri and so can whole kits of parts. The writer has had some success with home made filters using Mullard pot. cores type FX1011 of A1 Ferroxcube. These were wound full with different gauges of wire until two were found that would give independent operation at the same time. For these experiments only 9 volts were used for the relay circuit, since the relay was a type that has given very satisfactory service at low currents. The closed circuit jacks J1 and J2 are for checking tone generator tuning and relay current. The receiver tuning can also be checked at this point.

The transmitter uses a 3A5 or DCC90 valve for the R.F. section, in a MOPA circuit, with crystal control (see Fig. 53). Another 3A5 or DCC90 is used as an amplifier modulator, which is fed from a tone generator. The coil L3 is connected by short leads to a lamp bulb of 6 volts .04 amps which is used as a tuning indicator. For tuning, the core of L1 is rotated to find a dip in the H.T. current as measured by a meter in the H.T. lead. This will be about 2 ma. at 20 ma. The condenser across L2 is then tuned to give the brightest glow from the bulb. The bulb should be removed or switched off before using the transmitter for flying or other model control. Another method would be to use a Field Strength Meter and tune for maximum strength.

The tone generators are shown for the two tones to operate simultaneously in Fig. 54. A suitable transformer available in England is the Ardente D239, but the lead colours are different. A workable arrangement was found to be Blue and Yellow instead of Red and Green for the primary and Red and Green instead of Green and White for the secondary. In the experiments carried out a lower tone was required and this was obtained by putting a condenser of .005 mfd. across the primary winding.

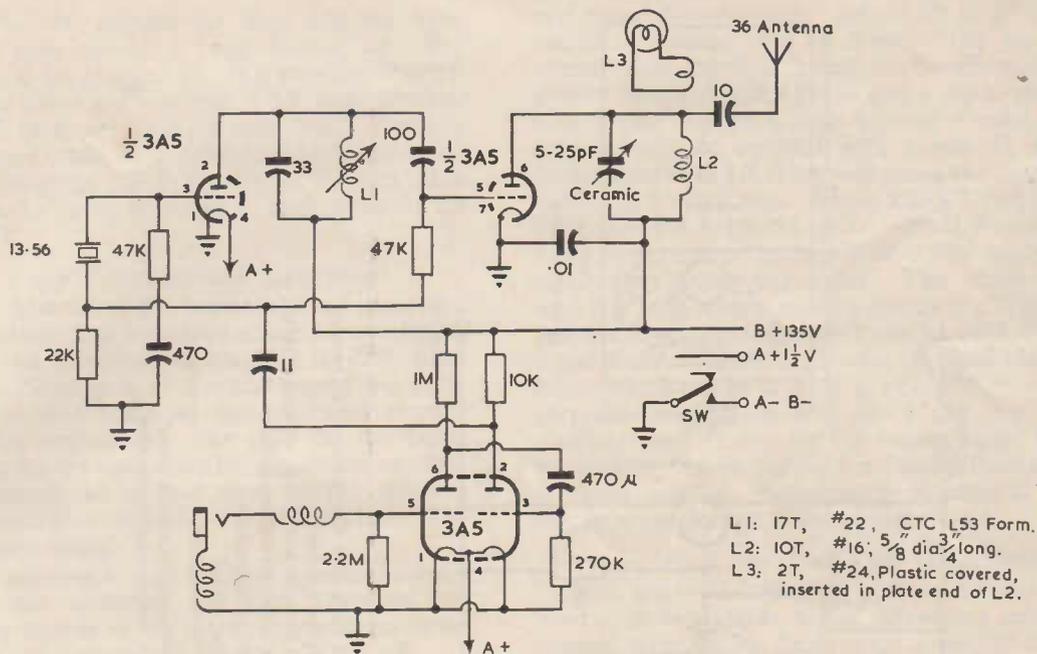


Fig.53

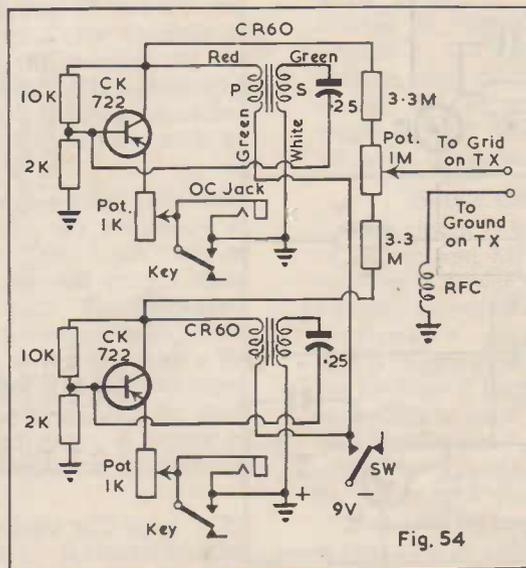
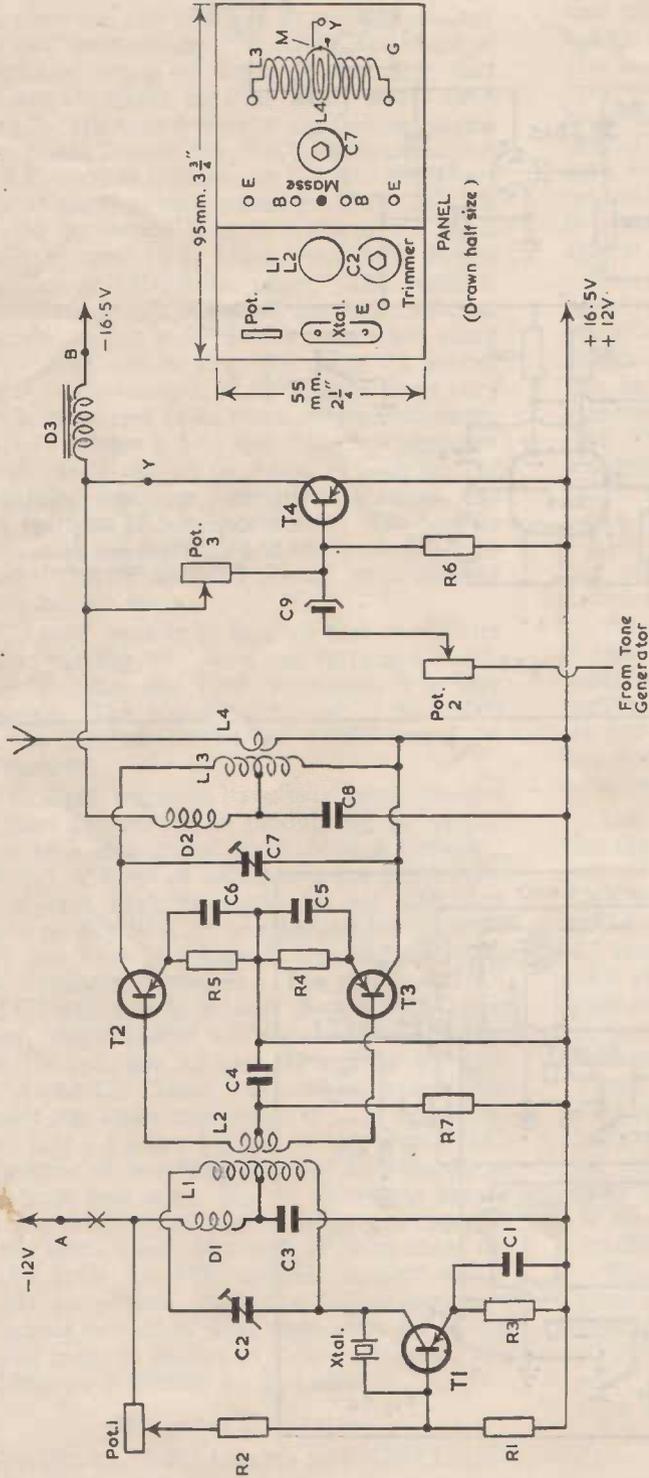


Fig. 54



- R1 : 10K.
- R2 : 47K.
- R3 : 180Ω.
- R4 : 180Ω.
- R5 : 180Ω.
- R6 : 10K.
- R7 : 3K.
- Pot.1 : 100K.
- Pot 2 : 5K.
- Pot 3 : 50K.
- Xtal: Overtone quartz.
- D1 : R.F. choke.
- D2 : R.F. choke.
- D3 : A.F. choke.
- C1, C3, C4, C5, C6, C8 : 1000pF ceramic.
- C2, C7 : 25pF Philips trimmer.
- C9 : 10 μ electrolytic.
- T1, T2, T3 : OC170.
- T4 : OC72.
- L1 : 16 turns, 0.32 wire, spaced 0.32, 1/4 former.
- L2 : 3 1/2 turns, 0.2 wire, 1/4 divided at centre.
- L3 : 16 turns, 0.6 wire 1/4, divided at centre.
- L4 : 4 turns, 0.2 wire between halves of L3.
- A and B : Meter positions.
- X : Key for carrier.
- Y : Key for modulation.
- D3 choke is high impedance side of valve receiver output transformer.

Fig.55

The 1K pot. adjusts the tone and the open circuit jack allows a push button, or other switch, to be plugged in. If a number of independent tones are required, a 1K pot., and key or O.C. jack, are used for each tone. Three or four tones could be obtained on each generator. The 1 megohm pot. is to balance the two tones to give the same response to each relay in the receiver.

#### *Fully Transistorised Equipment*

The first news the writer had of successful transmitters and receivers using all transistors was at an International meeting in 1958 when Mr. E. Nievergelt of Zurich loaned his notebook so that some of the following circuits could be copied out. Not only the notebook, he also loaned the writer his spectacles to allow the diagrams to be read more easily! Such is the friendliness of Radio Controlled Model Aircraft enthusiasts.

Mr. Nievergelt was the first man in Switzerland, and probably the first anywhere, to publish details of an all transistor transmitter for the radio control of models.

He does not wish to claim all the credit for these circuits. He has taken other people's circuits and experimented with them. Taking the transmitter first, Mr. Nievergelt saw a transmitter circuit called "The Mighty Milliwatt" in an article by Mr. Don Stoner in "Radio and T.V. News", and this inspired him to develop an all transistor transmitter for model radio control. The circuit Fig. 55 was the outcome and with the all transistor receiver of Fig. 56, the range with the receiver on the ground was over 1,000 yards. The transmitter has been operated on more than one occasion for a continuous period of 2 hours with an ambient temperature of 22° C.

The transmitter is quite straightforward, using a transistor oscillator, the frequency of which is stabilised by an "Overtone" quartz crystal. This feeds a push-pull output stage which is collector modulated. The modulator is driven by a tone generator which is stabilised by a tuning fork, this being for use with a receiver employing a reed unit for multi-control. A separate tone generator is needed for each reed, though only one is shown. A layout of the tuning circuits components on the panel is shown, full size, in Fig. 55.

When built, this transmitter will need to be tuned in the following order. A meter, reading up to 10 ma., is put in the negative lead of the 12 volt supply at point A. Another meter, reading up to 20 ma., is put in the 16.5 volt negative lead at point B. Set pot. 1 to full resistance, C2 to low capacity, modulation off,

and aerial disconnected. Adjust C2 to give an oscillator current of 4 to 5 ma. The output current will rise but should not be allowed to exceed 10 ma. Adjust C7 to give a dip to about 2 to 4 ma. A cycle lamp bulb of 6 volts .04 amps should be coupled with 1 turn of wire in the middle of L3. This will cause the current to rise to 8 or 10 ma. Adjust C2, C7 and Pot. 1 to give the brightest glow. Final tuning is best carried out with the aid of a field strength meter after fitting the aerial. This aerial can be 4 feet long with a loading coil in the middle. A 6 feet long counterpoise should be used. Pots. 2 and 3 are adjusted to give the required modulation which can be from 80% to 100%. Normal current consumption will be 4 ma. for the oscillator and 13 ma. for the output stage. The transmitter can be pulsed for mark/space proportional control. Switching is at point X for carrier wave and at Y for modulation.

#### *Tuning Fork Stabilised Tone Generators*

Tone generators for use with reed receivers need to be very stable, so Mr. Nievergelt experimented with tuning forks with a circuit from Mr. Sauter of Zurich as a basis. This to be fed into the modulator stage of the transmitter just described.

The tone generator is shown in Fig. 57. The feedback circuit goes through a tuning fork and the frequency of oscillation will therefore be that of the natural vibration of the particular fork used. This gives very good stability of the audio frequency though it does mean a little trouble in tuning the fork and the reed to vibrate at the same frequency. There is no reason why other types of tone generators should not be used, especially for use with single control tone receivers such as the next set to be described.

#### *Single Control Tone Receiver*

This circuit is based on one from Mr. Blatter of Zurich and Mr. Nievergelt says it will work well on a lower voltage with the SB100 (or similar) transistor and a suitable change in the bias resistor. It is a super-regenerative reflex and is shown in Fig. 56. It is not recommended for beginners, because with such a circuit some components may need altering slightly to get best results due to differences in transistors and other components. Some adjustment is allowed by the two 5K pots.

It should be possible to use this receiver with a reed unit in place of the relay. The 16 mfd. condenser would need to be removed, and a smaller one placed across the reed unit. About .5 mfd. could be tried, the best value being found by experimenting to tune the unit to the particular reeds used.

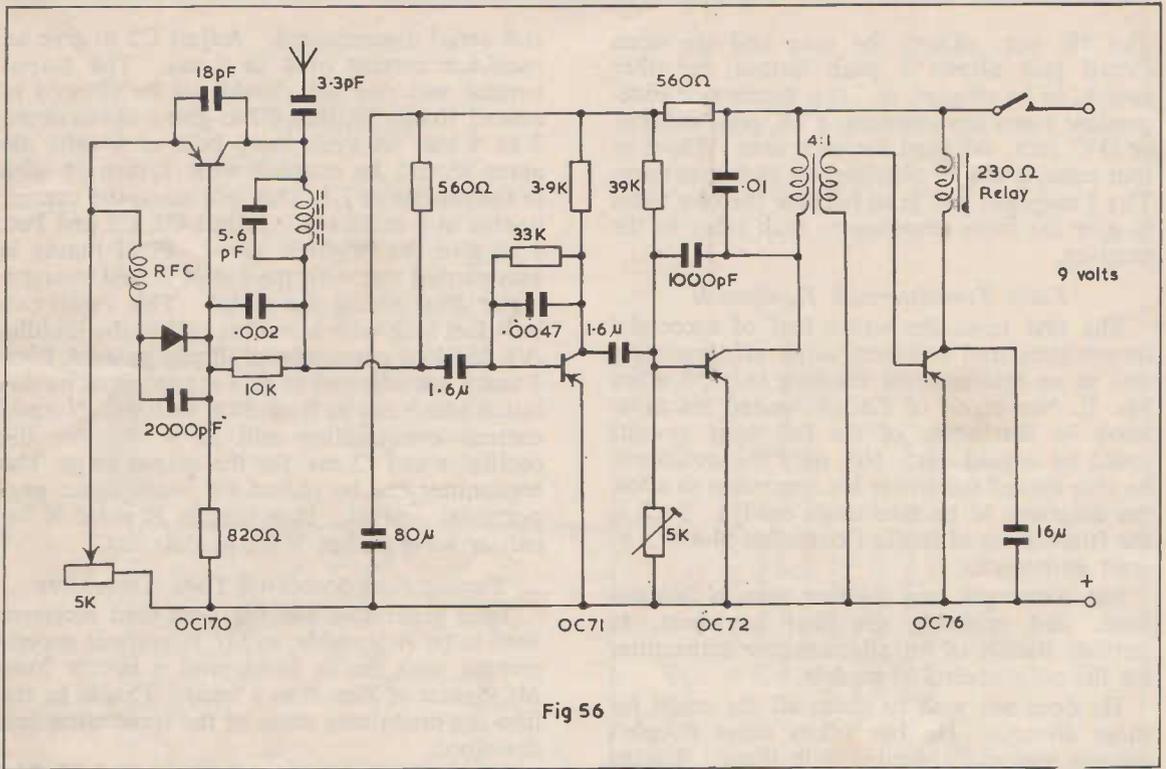
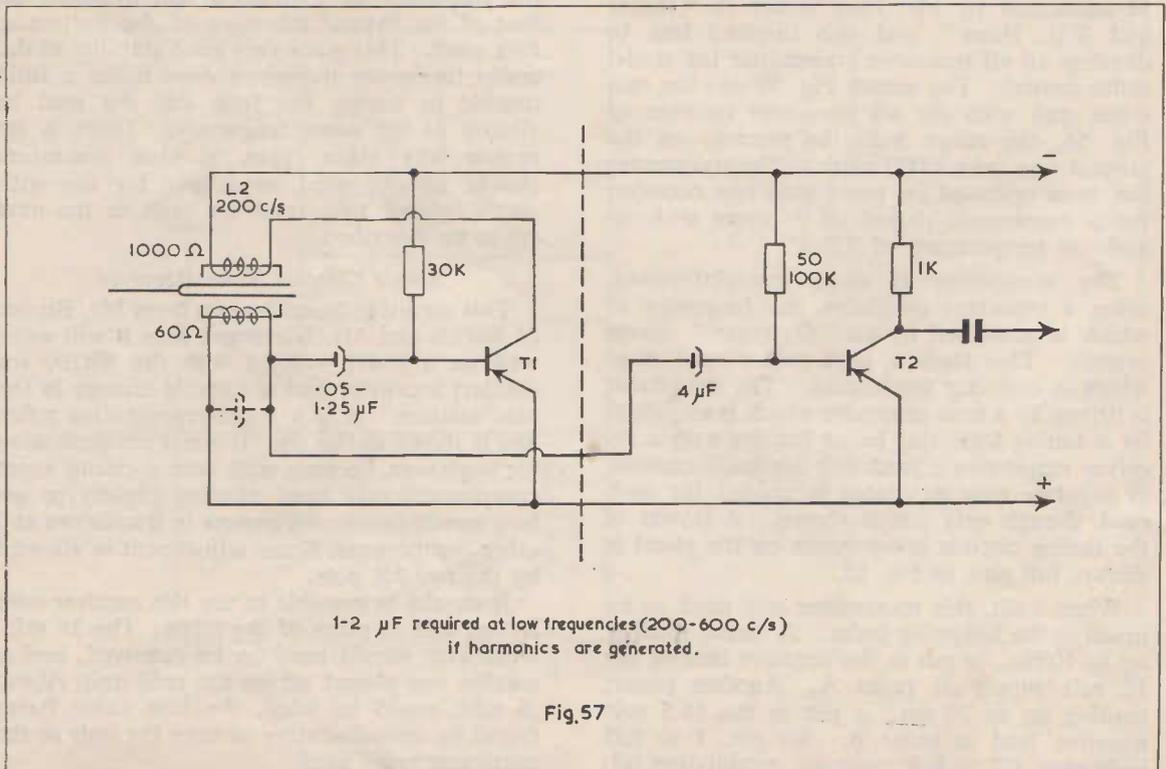
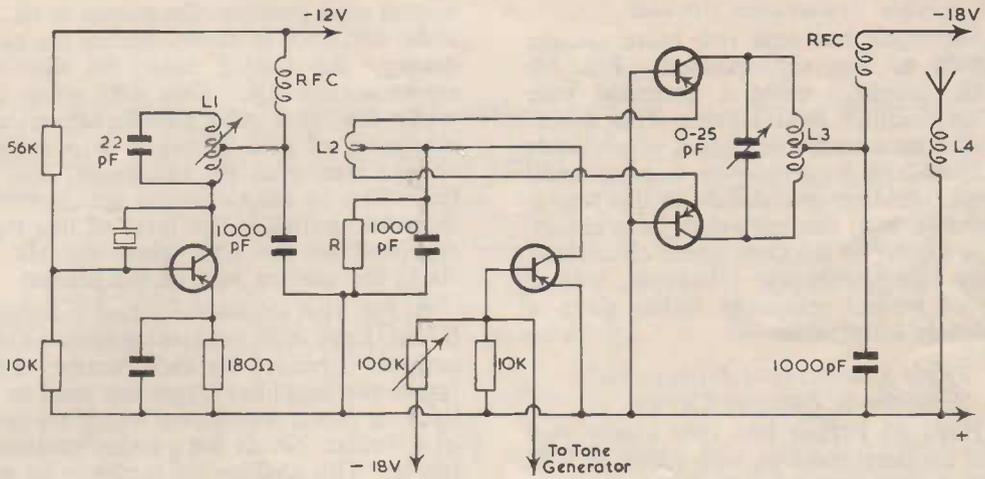


Fig 56



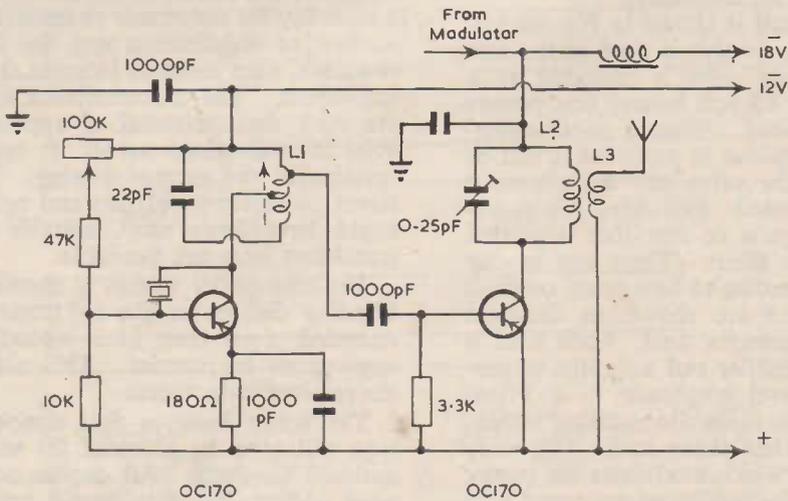
1-2 μF required at low frequencies (200-600 c/s)  
if harmonics are generated.

Fig.57



- L1: 18T, 21 s.w.g., 7mm Former, Dust Iron core centre tapped.
- L2: 3T, Flex. Centre tapped on L1.
- L3: 16T, 16 s.w.g.  $\frac{1}{2}$ "  $\frac{1}{2}$ " divided at centre.
- L4: 4T, 24s.w.g. between halves of L3.
- R: 47-180Ω.

Fig. 58



- L1: 18 turns 21 s.w.g. on 7mm Former.  
Top at 3 turns & centre.
- L2: 19 turns 21 s.w.g. on 12mm Former.
- L3: 5 turns round end of L2.

Fig. 59

### *Further Transmitter Circuits*

Mr. Nievergelt has sent two more circuits with which he has experimented. Fig. 58, shows the amplifier using a grounded base circuit, and emitter modulation. This avoids the use of a transformer or choke, which needs to be rather large in proportion to such small equipment. Emitter modulation in this way is only possible with the grounded base circuit. Fig. 59 is similar to the Don Stoner circuit and uses only two transistors. However, with a receiver of normal sensitivity it has given a range of over 1,000 yards.

### *A Triple Simultaneous Proportional Equipment Receiver Circuit*

Jan Hajic of Prague has very kindly sent details of his latest receiver, with which he feels very satisfied, because he says he does not intend to try to improve the radio equipment. Instead, he will concentrate on improving the model and his flying. Jan has already won National contests and represented Czechoslovakia in International and World Championship contests. His radio equipment has always been his own design and construction (and his model aircraft) and the reliability has been proved.

The description of this equipment and its working has been made possible by Jan Hajic's wife Eva, who did all the translation including all the technical terms necessary.

The receiver circuit is shown in Fig. 60 and it will be seen that a valve is used in the first stage. H.T. for this valve is provided by a converter from the 4.5 volt battery that powers the rest of the receiver. When a suitable temperature stable transistor is available it will be used in place of the valve and the converter will not then be needed. Following this super-regen. detector stage is an amplifier stage that feeds the band-pass filters. There can be one or two or three according to how many controls are wanted. Three are shown to illustrate more fully the frequencies used. Each filter is followed by an amplifier and a limiter to provide a constant level amplitude to a Travis discriminator. This feeds the actuator circuit.

The transmitter has three audio frequency oscillators, each of which modulates the carrier 35%. The coils of the oscillators are tuned with ferrite cores which slide in and out. These cores are coupled to the control stick so that movement of the stick sends the frequency up and down within limits, about a mean, for each control. The bandpass filters in the receiver tune to the required bandwidths. The output from the Travis Discriminators depend on the frequencies received. If the mean frequency is transmitted, corresponding to

neutral stick position, the output is nil. If the audio oscillator is de-tuned from the mean frequency, the output from the discriminator varies accordingly. One side going positive while the other side goes negative, up to a maximum of plus or minus 0.15 volts. This voltage then goes up and down, one side or the other, in proportion to the movement of the control stick. The level of this output is regulated by the 1.6K ohm variable resistor  $R_r$  in the emitter lead of the limiter.

In Fig. 61 is shown the actuator circuit which is fed from the receiver output. One such actuator is needed for each control. From the input, two amplifier stages are used to control the four power transistors, which are connected in a bridge circuit for passing current to the motor. This enables the motor to be reversed. Coupled to the motor through a suitable reduction gear is the lever to operate the control and also a 2000 ohm variable resistor which biases the input transistors. A state of balance is brought about when the motor has rotated a certain amount depending on the input from the receiver. At this point the control on the model has taken up a position relative to the control stick position and there is practically no current flowing through the motor.

Due to the difference in current flow through the motor in the running and stationary conditions, and the inertia of the armature, there was a tendency for the circuit to oscillate. The best method of stabilisation was the fitting of the two 220K ohm resistors between the motor and the inputs. The characteristics of the 5NP70 are such that potential of approximately 0.5 volts is maintained across its terminals irrespective of the current flowing. While a different arrangement of pnp and npn transistors could have been used, suitable npn power transistors were not available.

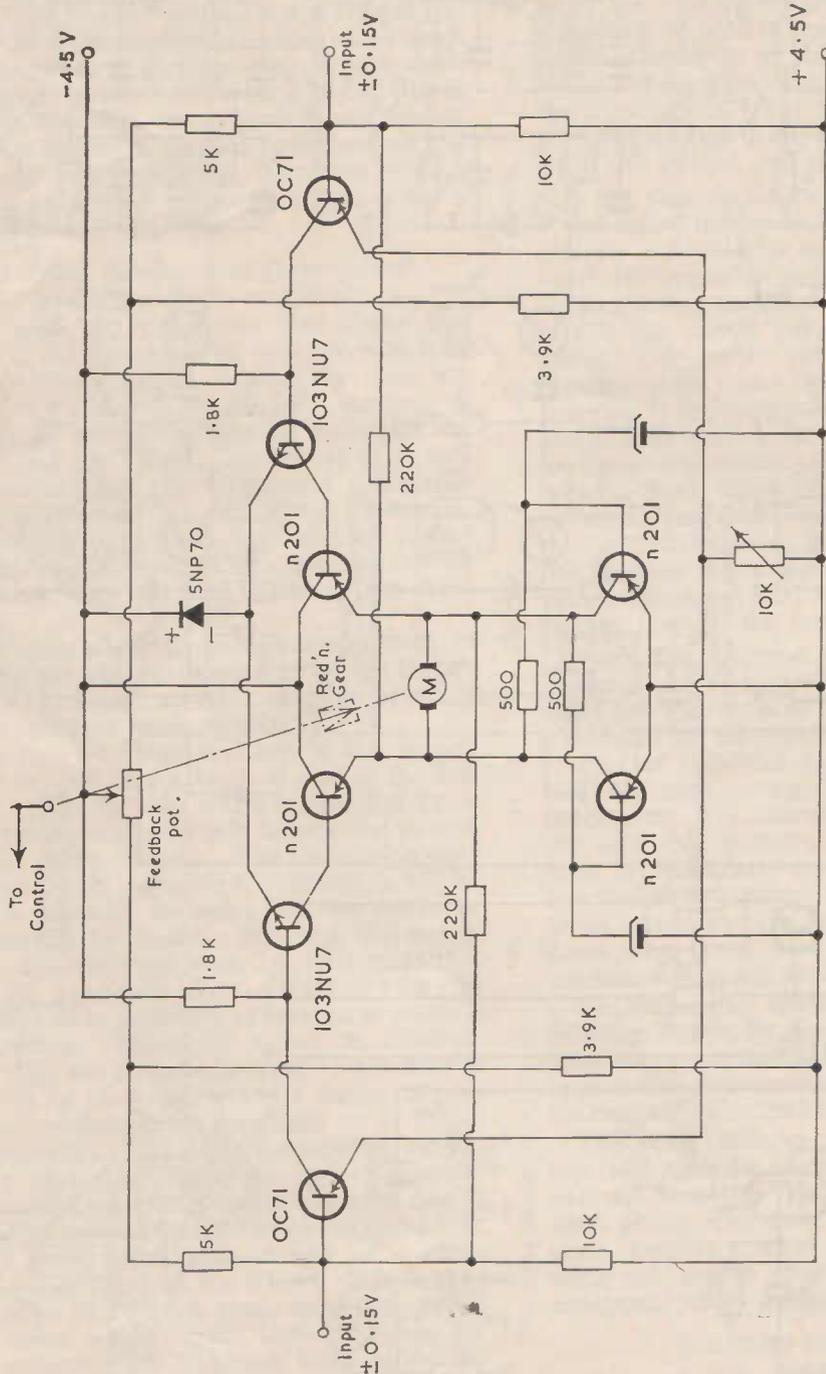
The transmitter circuit is shown in Fig. 62. Winding details for the inductances were not recorded, since they were wound to suit the appropriate frequencies. This also applies to the receiver inductances.

The writer believes that equipment of this type will soon be essential for winning International Contests. An engine control would need adding, but that would not be difficult since another control could remain neutral while the engine speed was changed. Such equipment seems a fitting close to this book.

### *Transistor Characteristics*

These are only approximate, some makers quote typical values while other quote minimum. More detailed information can be obtained from the various makers.





M-motor: 2.5 to 3.5V, 300mA max.

Fig. 61



## TRANSISTOR CHARACTERISTICS

Type	Frequency	Gain	Max. V	Max. Ic.	Max. Diss.
GT41	3 mc/s	30	9		100mW.
GT42	5 mc/s	60	9		100mW.
GT43	7 mc/s	100	9		100mW.
OC16		30	32	3 amps.	8W.
OC71		40	30	50 ma.	100mW.
OC72		70	32	250 ma.	120mW.
OC76		45	30	125 ma.	200mW.
OC170	70 mc/s	80	20	10 ma.	70mW.
OC171	100 mc/s	80	20	10 ma.	70mW.
SB100	45 mc/s	20	4.5		10mW.
SB305	25 mc/s	25	2.5	3 ma.	10mW.
SB344	40 mc/s	20	5	10 ma.	20mW.
SB345	50 mc/s	35	5	10 ma.	20mW.
V6 2R	3 mc/s	30	6	30 ma.	125mW.
V6 4R	5 mc/s	50	6	30 ma.	125mW.
V15/10P		10	15	3 amps.	10W.
XA131	100 mc/s	60	30	10 ma.	85mW.
XA702		50	15	400 ma.	125mW.
XB103	2 mc/s	66	35	50 ma.	120mW.
XB105	2 mc/s	60	12	50 ma.	90mW.
XC101	5 mc/s		35	50 ma.	90mW.
XC121	30 mc/s		25	10 ma.	50mW.
2N35	10 kc/s	125	25	100 ma.	150mW.
2N217		150	25	70 ma.	150mW.
2N224		90	25	15	250mW.
2N229		25	10		50mW.
2N247	30 mc/s	60	35	10 ma.	35mW.
2N1038		60	30	3 amps.	20W.
Red Spot	800 kc/s	30	15	50 ma.	125mW.
White Spot	2 mc/s	50	15	15 ma.	125mW.
Green/Yellow		30	10	30 ma.	200mW.
Red/Yellow	2 mc/s	50	10	30 ma.	200mW.

## Diodes

SJ301 Peak inverse volts 300  
 CG44 P.I.V. 80  
 MS1-H P.I.V. 60

max. I, 1 amp type A, 2 amp. type B.  
 max. I, 30 ma min. forward I 3 ma.  
 max. I, 250 ma.

# BERNARDS

## BOOKS ON

# TRANSISTORS

**No. 148. PRACTICAL TRANSISTOR RECEIVERS** by Clive Sinclair 5/-  
 Size 10" x 7½" 56 pages 36 plans and illustrations

Of the 50 or so different receivers described and illustrated here, more than 40 were designed, constructed and tested in the Bernards Laboratories by the author himself. The remainder were designed in the development laboratories of a number of well-known firms. The book covers all types of receiver other than the superhet and begins with several simple single transistor receiver designs and progresses through to more complex types for short wave and broadcast band reception. Each circuit diagram is accompanied by a comprehensive, simple to follow, description of its mode of operation and particular advantages. Each type of receiver has its own section in the book which commences with a detailed analysis of that type of receiver together with an explanation of advantages and disadvantages to be found in its use. An appendix gives technical specifications of British and American transistors most readily available together with a list giving British and Continental equivalents for for a very large number of American types.

**No. 151. TRANSISTOR SUPERHET RECEIVERS** by Clive Sinclair 7/6  
 Size 10" x 7½" 96 pages

This is the first book ever to be published dealing completely with transistor superhets. The first section deals in considerable detail with the various types of circuit found in transistor receivers throughout the world, as well as a considerable number of types of circuit which have not yet been used commercially. Over 50 complete circuit diagrams are given as typical examples of the commercial products both in the kit and manufacturing form of Great Britain, U.S.A., Europe and Japan. The book also covers in considerable detail components, servicing and construction of Transistor Superhet receivers. There is a comprehensive list of terms used in relevant technical literature. Technical specifications are given for all transistors used in British, American and European receivers as well as an up-to-date replacements equivalent list for transistors made anywhere in the world.

**No. 156. TRANSISTOR CIRCUITS MANUAL No. 1** by I. F. Gregory 2/6  
 Size 7½" x 5" 32 pages 8 circuits 24 plans and illustrations

Many people who have wished to gain experience in transistor constructional work have been deterred from doing so for want of authoritative information on this subject in sufficiently simple terms. That lack is now filled by this admirable book by I. F. Gregory. The author's many years of experience in transistors gives him a greater insight into the problems of the Home Constructor than the majority of authors. Full constructional details are given for several radio sets some of which are only the size of a packet of 10 cigarettes, and one of which is operated by readily available solar cells. Another very interesting project is the telephone amplifier which enables a number of persons to listen to the telephone without any connection being made to the instrument.

**No. 163. TRANSISTOR CIRCUITS MANUAL No. 2** by Clive Sinclair 2/6  
 Size 7½" x 5" 44 pages 20 diagrams

This is the second of the transistor circuits manual series and, like the first, it provides circuit details and constructional data for a large number of transistorised units. As this book deals with some slightly more advanced projects than Book 1, technical descriptions of the mode of operation of the circuits are included, as well as the purely constructional details. The common denominator of the circuits is originality so that the purchaser is bound to find a lot in it which he has never seen before.

**No. 167. TRANSISTOR CIRCUITS MANUAL No. 3** by Clive Sinclair 2/6  
 Size 7½" x 5" Fully Illustrated 10 diagrams and circuits

This is the third in the transistor circuits series giving many applications for commercially available pre-assembled transistorised printed circuit units as follows: 8 transistor, 3 waveband superheterodyne receiver; 1 watt amplifier; stereo amplifier; intercom; baby alarm; loudhailer; guitar amplifier; signal tracer, etc.

**No. 168. TRANSISTOR CIRCUITS MANUAL No. 4** by Clive Sinclair 2/6  
 Size 7½" x 5" 40 pages 17 diagrams

The fourth transistor circuits manual is similar in format to the second, circuit diagram and constructional data being given for the following:—Subminiature 3 transistor regen., 5 Kc/s to 2 mc/s signal injector, 15 watt public address amplifier, 5 miniature power packs, a 1-transistor regen., high resistance voltmeter, simple earpiece reflex receiver, 2-transistor superhet, 1-transistor transmitter, Hi-Fi preamp. for tape and disc and a 3 watt Hi-Fi amplifier.

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This unit has an overall size of only  $1\frac{3}{4}'' \times \frac{3}{4}'' \times \frac{1}{8}''$  yet by using a new type of ferrite of very high gain and first grade Litz wire a sensitivity has been achieved which is as good as a normal 6'' ferrite rod aerial. Thus, by using this rod, a pocket set can be made having the same sensitivity as a full size table radio. This aerial is ideal for use in any pocket or portable superhet, T.R.F. regen. or reflex circuit. Since the inductance is adjustable, it may be used with any tuning capacitor from 150 pf. to 500 pf. in value.

Size:  $1\frac{3}{4}'' \times \frac{3}{4}'' \times \frac{1}{8}''$ .

Turns ratio and current gain: 10 to 1.

Inductance range (varied by sliding coil along rod): 200-440 uH.

Q-Factor: Better than 240.

Colour code: Primary—yellow & blue.

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One of the main difficulties involved in building sub-miniature receivers is the difficulty of obtaining a suitable and attractive case. We have now remedied this situation by making available a clear plastic box. This may be painted inside, in any colour or colours, to produce a durable and attractive finish. Holes may easily be drilled as required and the case will accommodate our new ferrite rod aerial and sub-miniature tuning capacitors. Size:  $2\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$ .

Retail price: 1s.

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# SUB-MINIATURE COMPONENTS FOR THE RADIO CONTROL MODEL BUILDER

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Overall length of socket— $\frac{7}{8}$ ".

Overall length of jack plug— $1\frac{1}{4}$ ".



Plug with Socket    Retail Price 2/6

### IF AMPLIFIER.    322-0002

This IF unit is mounted on a printed circuit board 2.17" by 4.53" long and .95" high. It has three I.F. stages and a symmetrical ratio detector tuned to 10.7 Mc/s. The voltage available at terminal 5 (I.F. strip) can be used for AFC and is applied to terminal 5 of the tuner (312-0002).

The range of the AFC, with a signal input of 10 microvolts is  $\pm 200$  Kc/s, 100 microvolts  $\pm 400$  Kc/s and above 1 millivolt  $\pm 500$  Kc/s. An advantage of this wide range is that voltage variations (between 11 and 14 volts) in the power supply, for instance, the car battery, will be automatically compensated when the input signal level is over 50 microvolts.

The FM de-emphasis circuit has not been included in the IF amplifier, thus allowing the designer or user to select the de-emphasis resistor for matching the input stage of the audio amplifier. This method has the advantage of eliminating a double loss in amplification. (All measurements were made with a de-emphasis combination of 10 K-ohm and .005 microfarads and a 10 K-ohm volume control, see Fig. 4.)

### FM-IF AMPLIFIER.    322-0002

Dimensions: 2" x 4.5" x 1"    Retail price 126s.  
Weight: 2.65 ozs.

T1, T2 and T3 supplied as part of this unit: OC170's.  
bandwidth at 6 db down and 250 microvolts input: 10.7 Mc/s.  
bandwidth at 6 db down and 1 millivolt input: 200 Kc/s.  
320 Kc/s.

Ratio detector with 0.6 volt on primary and  $\pm 22.5$  Kc/s frequency deviation.

Peak distance: 250 Kc/s.  
DC voltage: 3 volts.  
AF voltage on 10 K-ohms: 10 millivolts.  
AFC voltage:  $\pm 0.5$  volt.  
Amplification 1st IF stage: better than 20 db.  
Amplification 2nd IF stage: better than 20 db.

Minimum guaranteed performance standard for combined tuner (312-0002)  $\pm$  I.F. strip (322-0002).

### 1.5 WATT TRANSISTOR A.F. AMPLIFIER TYPE 324-0004

This 3-stage, push-pull A.F. amplifier was designed to operate from a 12 volt supply with the negative side of the battery at ground potential. It matches the FM tuner and I.F. amplifier just described and is particularly suited for use in record players, audio systems, intercoms, etc. Full output is available at up to 45°C.

Operating voltage: 12 volts.  
Maximum output with 3 ohm speaker: 1.5 watts.  
Maximum output with 5 ohm speaker: 1.2 watts.  
Input voltage for 1.5 W output: 2 mV.  
Input impedance: 2 K-ohm.  
Frequency response  $\pm 3$  dB: 200 c/s to 12 Kc/s.  
Size:  $2\frac{1}{4}$  x 3 x  $1\frac{1}{8}$  ins.  
Retail price: 97/6d.

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# **Radio, Television, Industrial Tube, Transistor & Diode Equivalents Handbook**

**By BERNARD B. BABANI**

**High Grade — Laminated — Square Back Binding — 3 Colours**

Designed for the utmost use with simplicity, this unique book presents interchangeability data on every Electronic Tube and Semiconductor available in the world to-day, and manufactured in any of the following countries:— Great Britain, U.S.A., Germany, France, Italy, Russia, Japan, Australia, Denmark, Switzerland, East Germany, Poland, Czechoslovakia, Belgium, etc.

Immediate equivalents are shown for every receiving valve including diodes, triodes, tetrodes, pentodes, heptodes, hexodes, tuning indicators, regulators, thyratrons, rectifiers, sub-miniature tubes, T.V. cathode ray tubes, industrial and military type transmitting triodes, tetrodes, pentodes, cathode ray tubes, klystrons, magnetrons, T.R. tubes, A.T.R. tubes, co-axial velocity modulators, travelling wave tubes, pulse-gas switching tubes, noise sources, microwave oscillators, reflex velocity oscillators, cavity tubes, pre T.R. tubes, counter tubes, forward wave amplifiers, magnet focused amplifiers, continuous wave amplifiers, frequency multipliers, etc., produced in the above mentioned countries and in addition every Army, Navy and Air Force Electronic Tube and Semiconductor is shown with its commercial equivalent irrespective of its country of origin and the most extensive C.V. listing is included with details of practically 7,000 types.

More than 20,000 electronic tubes or semiconductors are covered in the data sections of this book and for the first time, a special Transistor Equivalents Table covering more than 2,000 types is provided.

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**THE GRAMPIANS,**

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# INTRODUCTION

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