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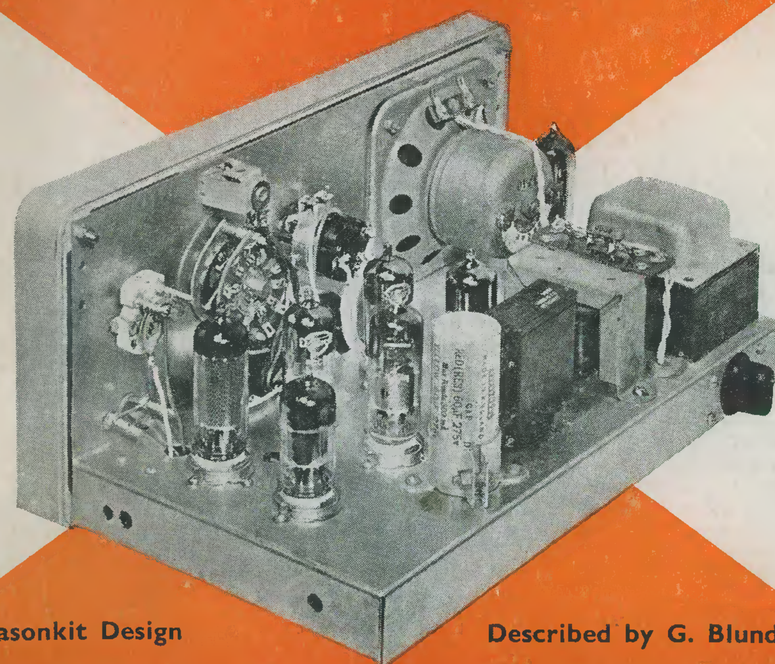
GETTING STARTED ON RTTY


VOLUME 13
NUMBER 4
NOVEMBER
1959


# The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

## CRYSTAL CALIBRATOR CC10



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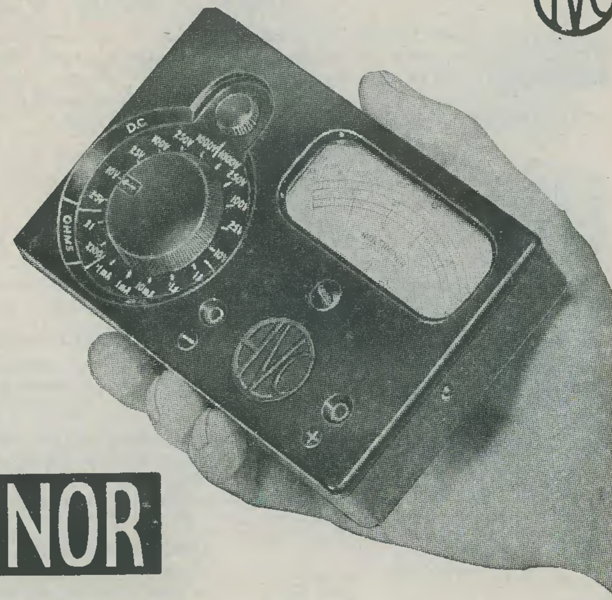

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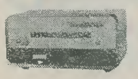

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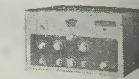

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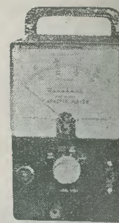

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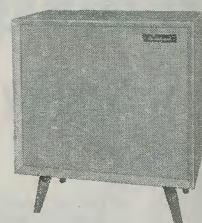

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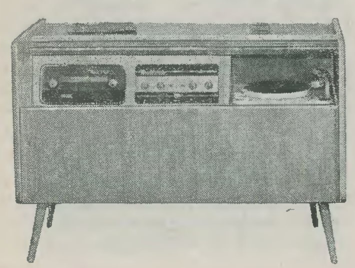

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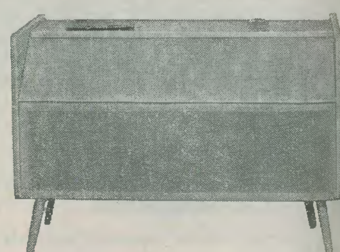

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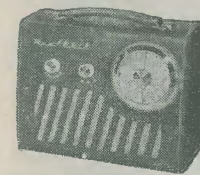

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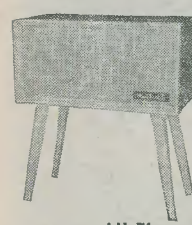

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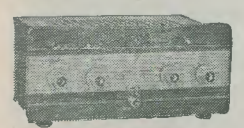

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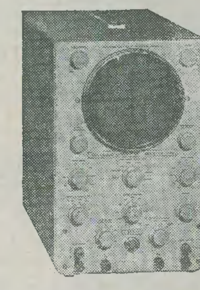
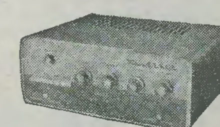
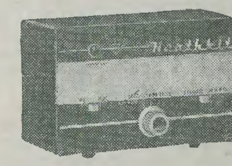


5″ OSCILLOSCOPE
Model O-12U



HI-FI STEREO AMPLIFIER S-88



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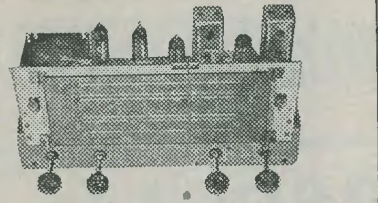

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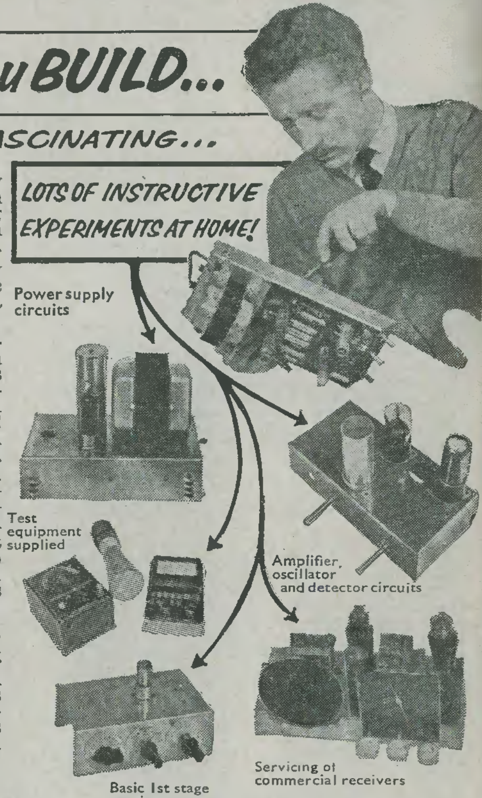


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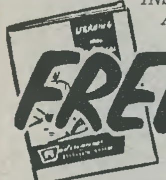

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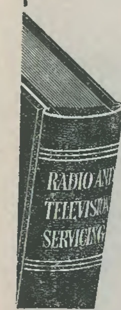

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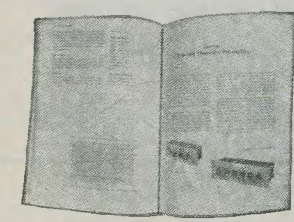

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THE EDITOR invites original contributions on construction of radio subjects. All material used will be paid for. Articles should preferably be typewritten, and photographs should be clear and sharp. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included.

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No. 108

# A Remote Volume Control for Television Receivers

# suggested circuits

The circuits presented in this series have been designed by G. A. FRENCH, specialy for the enthusiast who needs only the circuit and essential data

WHAT WOULD VERY PROBABLY BE THE ideal television receiver would be one which, amongst other things, allowed all the more important controls to be situated immediately under the hand of the viewer. The set-owner would then be able to change channels, adjust contrast and brightness, and control volume level without moving from his chair. In point of fact, the design and production of television receivers having remote control facilities raise few technical problems: such receivers have, indeed, been available in the domestic market for quite some time, notably in the States. Unfortunately, the provision of remote control facilities results in a relatively large increase in overall receiver cost, with the consequence that these facilities tend to fall into a "de-luxe" category.

The writer feels that the usefulness of a television receiver may be very considerably increased if only *one* aspect of its performance is made capable of remote adjustment by the viewer. This single aspect is the audio volume level of the receiver. The arguments in favour of a remote volume control are, to the writer's mind, rather compelling. It could cope very readily, for instance, with those instances where there are large differences in apparent volume level of the type which occur in programmes where speech and music are interspersed. If, when receiving such programmes, the local volume control is adjusted for comfortable level on speech, subsequent musical items frequently tend to be almost distressingly loud. Apart from the vexation caused by this effect to the more discriminating viewer, there is the fact that annoyance to others may result. The latter point is especially important if domestic conditions necessitate receivers being operated in crowded blocks of flats, or where children close by have to get to sleep. A remote volume control overcomes these drawbacks, enabling the receiver to be operated at comfortable listening level, both for speech and for music, with no risk of annoyance to others. A second point is that the television receiver is by no means always the focus of a family's attention. When visitors call, for example, it is quite often desirable to be able to turn down the volume on the receiver easily and unobstrusively whilst introductory conversation is in progress.

This month's contribution deals with a simple modification which may be made to any conventional television receiver in order that remote volume control may be achieved.

## Connecting Into The Receiver

Practically all modern television receivers employ an a.f. section which consists of a triode voltage amplifier followed by a pentode output valve. The input for the voltage amplifier is obtained from the sound detector, and it is customary to place the receiver volume control between this detector and the voltage amplifier grid. At first sight it would appear desirable to connect the remote volume control also into the grid circuit of the voltage amplifier. Unfortunately, coupling into this part of the circuit raises several problems. To begin with, since the full gain of the a.f. section is provided after the voltage amplifier grid, special care would be needed to prevent hum pick-up in the leads to the remote volume control. Due to this question of hum pick-up, it would also almost certainly be necessary for the outer conductor of whatever screened cable was employed in the leads to the remote volume control to be bonded direct to chassis. The screened cable outer conductor, in consequence, would become connected directly to one side of the mains, and the resultant shock hazard becomes unnecessarily high.

An alternative section of the receiver into which the remote volume control could connect is the sound output transformer secondary circuit. Ignoring the safety question (which would be dependent upon individual receiver design so far as isolation from chassis was concerned) there is, in this case, the disadvantage that the output valve would always have to operate at a level at least as high as the highest normally required; with the result that overall distortion would tend to increase. A further disadvantage is that the remote volume control would have to be of a special type which maintained correct matching between output valve and speaker if further distortion were to be avoided. A simple resistive potentiometer control would not cope adequately here.

In the circuit proposed here, the remote volume control is coupled into the grid circuit of the output valve. Coupling into this part of the receiver provides the advantage that subsequent a.f. gain is not of such an order as to cause much difficulty with hum pick-up. Also, the only stage which has to continually operate at a level at least as high as the highest normally required is the voltage amplifier. The risk of distortion incurred here should be negligible. Finally, it is possible to take circuit precautions which, whilst not eradicating shock hazard altogether, do at least provide a significant reduction in this risk.

A separate feature of the circuit is that a single screened lead is all that is needed between the remote volume control and the receiver, thereby considerably simplifying wiring requirements. It is recommended that this lead be normal coaxial cable, since the relatively low capacity between conductors in such cable will cause minimum attenuation of the higher audio frequencies.

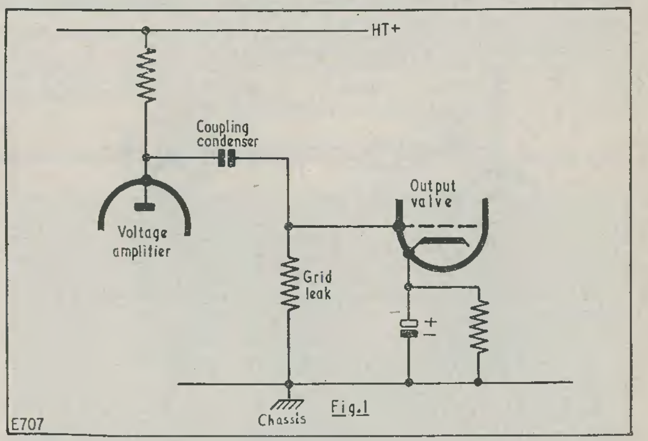



*Fig. 1. Receiver circuit before modification*

## The Modification

Fig. 1 illustrates the basic circuit likely to be encountered between the voltage amplifier and output valve of the receiver it is intended to modify. As may be seen, circuit arrangements are quite straightforward. The voltage amplifier connects to the h.t. positive line via its anode load resistor, and couples to the following grid via a condenser. The output grid is kept at chassis potential by means of its grid leak. In some receivers it may be found that the output valve cathode shares the same cathode resistor as is used by the voltage amplifier, but this point does not affect the modification. Again, it may occasionally be found that a low value tone-correction condenser couples between the output anode and its grid, or that a grid stopper resistor is inserted between the coupling condenser and the output grid. Where encountered, such components are retained during the modification, the feed-back condenser remaining connected between output anode and grid, and the grid stopper remaining connected to the grid. In the latter case, all connections to the grid, after the modification circuit has been installed, are made via the stopper.

Fig. 2 shows the circuit after modification. The first thing that should be noted is that the grid leak has been removed. Also, the coupling condenser now connects to the grid via the additional 100kΩ resistor, $R_1$. Further connected to the grid is the centre conductor of the coaxial cable which travels to the remote volume control, $R_2$. The outer conductor of the cable couples to chassis via $R_3$ and $C_1$.

couples into a circuit which consists effectively of $R_1$ on its own. The output grid is then virtually at chassis potential, and no a.f. is passed to it. Thus, maximum volume is obtained when $R_2$ inserts maximum resistance into circuit, and minimum volume is obtained when $R_2$ inserts minimum resistance into circuit. Settings of $R_2$ between maximum and minimum resistance will then result in corresponding volume levels between these extremes, and the function of a volume control is achieved.

### Circuit Features

One or two points need to be discussed more fully so far as Fig. 2 is concerned.

As has probably already been realised, the reason for inserting $R_3$ and $C_1$ into circuit is that a direct connection to the receiver chassis is thereby avoided. $C_1$ has a low reactance at the audio frequencies likely to be handled by the television receiver, with the consequence that the outer conductor of the coaxial cable may be considered as being at chassis potential so far as a.f. is concerned.

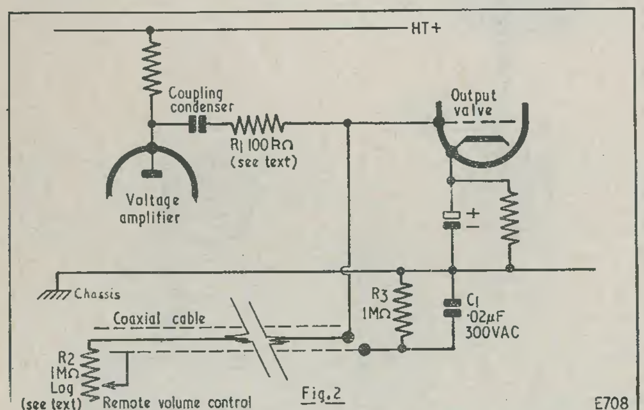



*Fig. 2. How the remote volume control is connected into circuit*

The functioning of the remote volume control is very simple. When the remote control is set to insert maximum resistance into circuit, the a.f. available at the voltage amplifier anode feeds into the potentiometer given by $R_1$ and $R_2$, the end of $R_2$ remote from anode being virtually at chassis potential due to the low reactance to a.f. offered by $C_1$. The output grid taps into the junction of $R_1$ and $R_2$, with the result that it receives $\frac{10}{11}$ of the a.f. voltage available at the anode.[1] When $R_2$ is adjusted to insert minimum resistance into circuit, the a.f. amplifier anode

At the same time $C_2$ provides a reasonable measure of isolation from the chassis so far as shock hazard is concerned, this isolation being of the same order as has been used in the past for pick-up and aerial connections in a.c./d.c. sound receivers. It must be pointed out, nevertheless, that $C_1$ does not provide isolation to the level *currently* accepted for metal conductors capable of being touched outside the receiver cabinet. In consequence, the coaxial cable between the receiver and the remote volume control must be well and reliably insulated, the insulation extending inside the television cabinet and inside the box containing the

[1] Resulting in a loss of approximately 0.8dB.



remote volume control. The latter should be made of an insulating material, such as wood or plastic, the remote end of the cable being securely clamped inside. It will be noted that $C_1$ is a 300 volts a.c. wkg. component, this being an obvious rating for an isolation condenser. It would be desirable for the coupling condenser to be changed for a component having this voltage rating as well. The function of resistor $R_3$ is merely that of ensuring the existence of a d.c. path between the output grid and chassis. With television receivers having better-than-average a.f. reproduction it may be found that the presence of $C_1$ gives slight bass boost at very low volume settings. This effect should be quite unnoticeable under normal listening conditions.

As was mentioned above, coaxial cable is employed because of its low capacity. This capacity is of the order of 20pF per foot,[2] and it should be possible in consequence to use lengths of up to 15 feet (=300pF), or even more, without incurring any excessive attenuation of the higher audio frequencies.

A log-law control is specified for $R_2$. Such a component should offer almost as "smooth" a control of volume as would be given if it were used as a true potentiometer in a conventional circuit.

A final point is that the values specified for $R_1$ and $R_2$ are those applicable to the case where the previous grid leak had a value around 470kΩ. In some receivers it may be found that the grid leak has a value around 200kΩ only. In such an instance the values of $R_1$ and $R_2$ should be halved.

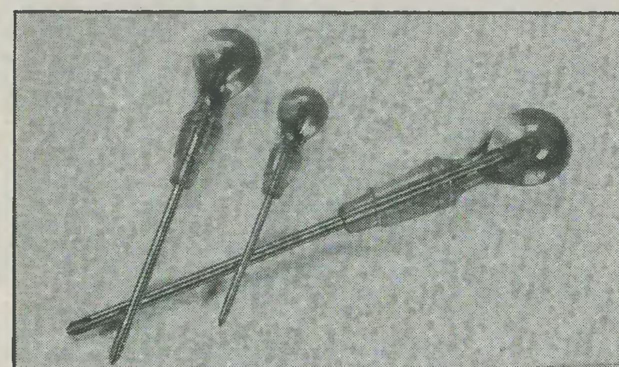
### Setting Up

After the remote volume control has been connected up it should be checked for operation. $R_2$ should be set to the maximum resistance position and the receiver adjusted to reproduce a programme. The receiver volume control should then be adjusted to a level slightly higher than that which would normally be required. It should then be found that $R_2$ will afford a range of control below this level.

It may occasionally be found that the modification causes hum to be introduced into the a.f. output of the receiver. This will occur if the chassis is at live mains potential, and the capacity between the coaxial cable and earth is sufficiently high to enable a hum voltage to be built up across $C_1$. The cure is to reverse the mains supply to the receiver.

[2] A sample of conventional solid-polythene spaced 75Ω cable, as employed for aerial lead-ins, had a capacity of 19.6pF per foot when checked by the writer.

# Trade Review



**STEADFAST SUPER HARD POINT PHILLIPS TYPE SCREWDRIVER**

CP.1—Overall length 5⅞in, suitable for Phillips recess head 4 SG wood screws, ⅛in, 5 and 6 BA metal screws.

CP.2—Overall length 8in, suitable for Phillips recess head 5-10 SG wood screws, $\frac{5}{32}$in, $\frac{3}{16}$in, 2 and 4 BA metal screws.

CP.3—Overall length 11¼in, suitable for Phillips recess head 12-16 SG wood screws, ¼in and 0 BA, and $\frac{5}{16}$in round head metal screws.

To give a much greater turning power cabinet type handles are fitted. These handles are made in unbreakable plastic and can be subjected to impact without fear of damage. The super hard point blades are particularly suitable for self-tapping screws.

Prices: CP.1 5s. 4d. each; CP.2 7s. 6d. each; CP.3 9s. 3d. each.

# IN YOUR WORKSHOP

*This month Smithy the Serviceman discusses, with his able assistant, Dick, the question of fuses*

"WELL, NOW," SAID DICK, "BUT THAT'S a funny thing."

"What's a funny thing?" grunted Smithy, over his shoulder.

"This hi-fi amplifier I'm modifying for you," said Dick. "You know, the one you asked me to fit with an h.t. fuse."

"Oh, yes, I remember," remarked Smithy. "However, a simple job like fitting a fuse shouldn't cause you much trouble."

"That's what I thought. I've got the fuse in circuit, but it has a tendency to blow every now and again when I switch the amplifier on."

"Any h.t. shorts?"

"Nothing," declared Dick, "that I can detect with an ohmmeter. Also, the amplifier worked quite happily before I put the fuse in."

"What is the fuse rating?" asked Smithy.

"200mA," replied Dick. "The amplifier takes about 100 to 120mA when it's running."

"Hmm," grunted Smithy. "Sounds a bit light, but it should be reasonable enough in practice."

## Charging Currents

The Serviceman walked over to the amplifier chassis which Dick had placed, inverted, on the bench. He noted that his assistant had drilled out a hole at the back of the chassis to take a panel-mounting cartridge fuse holder, and that he had wired it into circuit neatly.

Smithy looked closer at the wiring.

"Ah," he remarked. "I see where you've gone wrong. You've put the fuse between the rectifier and the reservoir condenser; with the result that initial charging currents to the reservoir condenser are liable to blow it if you switch on again shortly after switching off, and while the rectifier's still warm. (Fig. 1 (*a*).) You should have put it between the choke and the smoothing condenser. (Fig. 1 (*b*).)"

"But surely," protested Dick, "you wouldn't get as much protection if you put the fuse after the choke. For instance, it wouldn't guard against the case where the reservoir condenser itself broke down. You get *complete* protection the way I've fitted it here."

"That's true enough," admitted Smithy, contemplatively, "and I think I had better qualify my statement by saying that you could keep your fuse in the position you've chosen if you use a type with a delaying action, such as the Bulgin cartridge 'Pak' fuse. A Bulgin 'Pak' fuse is intended for applications where surges are liable to occur and it will withstand an overload of 75% for approximately 120 seconds. If the overload is of the order of 100 to 175% it blows within 5 to 30 seconds, and if it is over 200% (that is, three times the fuse rating) the fuse blows instantaneously. In your case I think a 250mA 'Pak' fuse would cope quite happily before the reservoir condenser."



"I'm getting a little baffled," complained Dick. "Why is it necessary to overload the fuse to make it blow? I always thought that if a fuse is marked with a certain current it always blows at that current."

"Not necessarily," replied Smithy. "The small glass 1¼in cartridge fuses we meet in radio work are usually marked with the maximum *carrying* current. You then have to look up the manufacturer's literature to find out the current at which they blow. Normally, you can be pretty certain that they'll blow at 100 to 200% overload, although this may not always be instantaneous. Your assumption that a fuse is marked with its blowing current does, however, apply to the types you find in cars—you know, the glass types with pointed brass end-caps. I thought you'd like to know that not all fuses are rated in the same manner."

This last sentence was accompanied by a grin on the Serviceman's face. He knew that his assistant was always irritated by discrepancies of this nature.

"Isn't it always the same?" grumbled Dick, rising to the Serviceman's bait. "You get one half of an industry making fuses which are rated for carrying current, and you get the other half rating fuses with blowing currents. Why can't these things be standardised?"

Smithy chuckled.

"Well, it *would* be nice to have it standardised," he admitted, "but with a thing whose performance is as complex as is that of a fuse standardisation tends to be a little difficult."

Dick interrupted him.

"Please, Smithy," he said, "don't let's get any more involved for the time being. Five minutes ago I was a happy lad who thought of a fuse as a bit of thin wire which burnt out if you screwed too many amps through it. Now I find I've stumbled on to a minor science all on its own. Isn't this one of the things that should be made the subject of a British Standard?"

"Perhaps so," said Smithy, cautiously. "In actual fact there are several separate British Standards for fuses of different types; but these tend to tackle their subjects from slightly different angles. The British Standard for the 1¼ cartridge fuses which we use in radio is B.S. 2950[1] and, amongst other things, this lays down several test require-

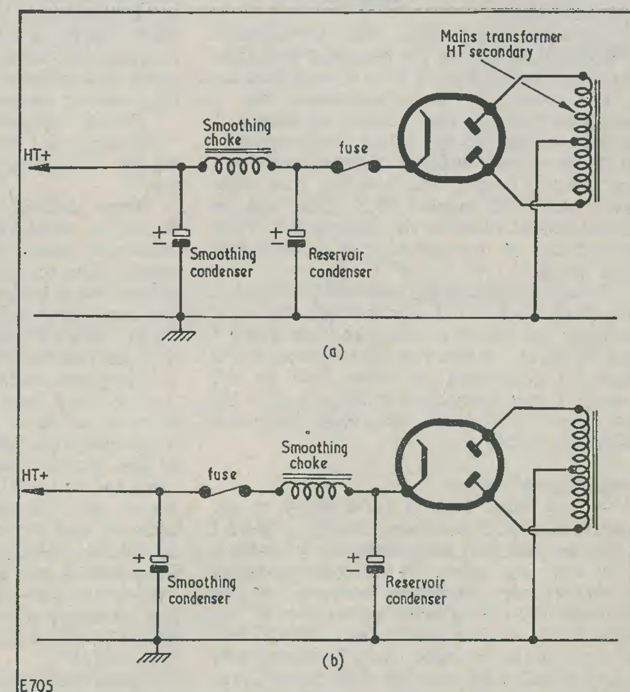



*Fig. 1 (a) A fuse inserted between the cathode of a rectifier and the reservoir condenser is subject to heavy switching-on surges (if the rectifier is warm or is a metal component) and has to carry the additional reservoir condenser charging current. A delay type fuse would be preferred in a circuit of this type. (b) When the h.t. fuse is inserted after the smoothing choke it is protected from switching-on surges and does not have to carry reservoir charging currents. However, the fuse does not offer protection if the reservoir condenser breaks down.*

[1]The full title of the Standard is B.S. 2950: 1958, Cartridge Fuse-Links For Telecommunication And Light Electrical Apparatus, and it supersedes the type B fuse-link requirements in B.S. 646: 1935. (The term "cartridge fuse-link" defines a cartridge containing a fuse-element.)

ments so far as current is concerned. I don't want to go into too much detail on the current tests, but I can say that these state basically that the fuse should carry its rated current for 1,000 hours without blowing. It should, also, blow within 10 seconds if its rated current is doubled, in the case of trade A fuses, or if it is trebled, in the case of grade B fuses."

"What's this grade A and B business?"

"Well," replied Smithy, "the two grades only apply to fuses between 50 and 250mA, which are, I suppose, rather more difficult to manufacture. Above 250mA the grade A requirement, that of blowing on double current rating, is the only one that holds."

"Does B.S. 2950 cover surge currents, like we've met today?"

"I'm afraid not," said Smithy. "It gives details of what is described as a suitable test, wherein the fuse is subjected to continuous surges, but this is for guidance only."

"Well, that's not very helpful," commented Dick.

"Perhaps not," said the Serviceman. "Nevertheless, I think the Standard does help to quite a useful extent, even if only because it ties down rating requirements for a particular type of fuse. Also, of course, I haven't mentioned the other things covered by the Standard—such as dimensions and so on. Don't forget, incidentally, that only fuses which are marked 'B.S. 2950' can be considered as meeting the Standard.[2] They should also be marked A or B according to their grade."

"Well, I suppose that's reasonable enough," remarked Dick, "but our learned discourse on fuses has rather clouded another query I had in mind. When you first looked at the way I'd connected up that fuse in the amplifier your immediate reaction was to tell me to put it after the reservoir condenser. Why was that?"

**Switching-on Surges**

"I may have been a little hasty in my judgment there," confessed Smithy. "And I do rather feel that the alternative of using a delay type fuse before the reservoir condenser is rather more attractive because, as you yourself say, it affords protection if the reservoir condenser goes kaput. What I had in mind at the moment when I saw the way you'd wired it up was the very heavy surge current which flows through the reservoir condenser and rectifier whenever you switch off and switch on again shortly after. Immediately after you switch off a piece of equipment having a valve rectifier, the charge on the reservoir condenser disappears due to the current drawn by the still-warm valves in the equipment, plus that drawn by any resistor networks which may be connected across the h.t. line. If you then switch on again, the rectifier, whose cathode may still be at emission temperature, has to pass a very heavy initial current during the first few half-cycles of a.c. until the reservoir condenser charges up to its normal voltage again. In your case the initial charging current was enough to blow your fuse, which was not, of course, of the delay type. Incidentally, you don't get the heavy initial charging current if you switch on equipment having a valve rectifier from cold. In this instance the rectifier cathode reaches emission temperature at a relatively slow rate and you get a gradual rise in charging current."

"What happens if you have a metal h.t. rectifier?"

"In that case," said Smithy, "there is no gradual warm-up and you get heavy initial surge every time you switch on. If I wanted to be pedantic, I could say that the greatest initial surge would occur if your switch contacts happened to close at the instant when peak positive voltage was being applied to a rectifier anode."

"That's interesting," remarked Dick. "Rectifiers and reservoir condensers take a bit of a bashing during their lives, don't they?"

"They certainly do," agreed Smithy. "I remember some years ago examining a little miniature radio which had come in for repair. This set, which was of rather doubtful origin, had a half-wave rectifier circuit which was absolutely cut down to the bone. (Fig. 2 (*a*)). When I checked around a bit I found that the rectifier valve had packed in. I was a little surprised by this at first, because it lit up O.K. and there were no shorts or flashes or any evidence of such things having happened in the past. In the end I had a look at the rectifier electrodes through its glass envelope and, so far as I could make out, I found that the internal wire between the cathode and the cathode pin lead-out had completely disappeared! There weren't any loose bits of wire in the envelope, so the only assumption I could make was that the owner had switched off and on again, whereupon the resultant surge current had just melted the wire away!"

"Well, that's a turn-up for the book."

"As you say," commented Smithy, gravely, "a turn-up, indeed. Anyway, I took the hint and, before inserting a new rectifier, I fitted a limiter resistor. (Fig. 2 (*b*)). The set went like a bomb with the new rectifier and, so far as I know, has not given any trouble since."

"Is, then, the purpose of the limiter resistor that of preventing initial surges?"

"Not entirely," said Smithy. "The current in the reservoir section of a rectifier circuit is always higher than that drawn after the smoothing choke because of the charging current, which appears at each positive half-cycle. The limiter resistor helps to keep this charging current to a reasonable value. If you look up manufacturers' data for valve rectifiers you usually find that they specify a minimum value of limiting resistor as well as a maximum value of reservoir capacity. You very often find something of the same nature with condensers, too. Double h.t. electrolytics frequently state on the can which section should be used as the reservoir, this section being that which is designed to handle the consequent charging currents."

"Would that accommodate the extra current in the reservoir circuit?"

"I think so," said Smithy. "The extra reservoir current is not all that great in a full-wave circuit because the reservoir condenser doesn't have a chance to discharge very much before the next positive half-cycle comes along. If it had been a half-wave circuit, in which the reservoir condenser is charged by every other cycle only, the extra current in the reservoir circuit tends to increase quite considerably. In such an instance you might find that a 250mA fuse in the position you chose would have rather a short life, and you would have had to go up to 500mA."

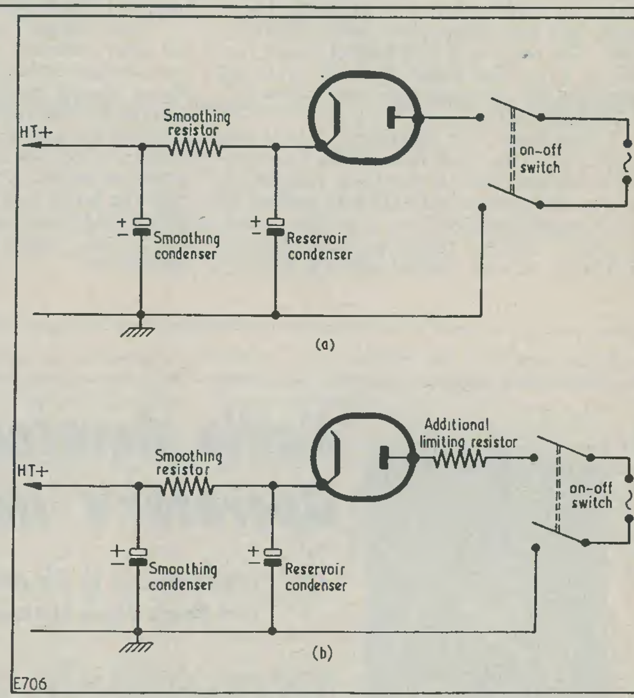



*Fig. 2 (a) An example of bad circuit practice, insofar that no limiting resistance appears in the reservoir circuit, either in the form of a physical resistor or in the form of "hidden" resistance in a mains transformer. If the on-off switch is closed whilst the rectifier is warm the resultant surge may easily damage the valve or the reservoir condenser. Also, reservoir charging currents may be excessive. (b) Inserting a limiter resistor prevents excessive initial surge currents and keeps reservoir charging currents within safe limits. The resistor would be just as effective if fitted between the rectifier cathode and the reservoir condenser. Its value would normally be that recommended by the manufacturer of the rectifier—a typical figure being of the order of* 200Ω.

"There weren't any limiting resistors in my amplifier power pack," Dick reminded Smithy.

"Nor were there," agreed Smithy. "But in this instance you had 'hidden' resistances in the mains transformer. These 'hidden' resistances are given by the actual resistance of the wire in the secondary, plus the effective resistance reflected from the primary wire and that resulting from the losses in the transformer."

"You recommended a delay fuse of 250mA in my case," Dick pointed out.

"But," protested Dick, "that would mean you'd need something like an amp to blow the fuse!"

"True," said Smithy. "Nevertheless, it would still provide useful protection for a metal rectifier, even if it wasn't of much use for the smaller type of valve rectifier. The alternative, of course, is to fit the fuse after the choke."

**Fuse Resistance**

"Another point has just struck me," said Dick. "If a fuse blows, it means that suffi-

[2] Old fuse-links may be marked with the superseded Standard: B.S. 646 B; or be advertised as meeting B.S. 646 B.

cient heat has been dissipated in its wire to cause it to melt. That argues a certain amount of resistance in the fuse. Could this resistance cause any trouble?"

"Not in the ordinary course of events," said Smithy, "although you should avoid using fuses in circuits which pass heavy currents and which require very low resistances. A typical instance of the wrong way of inserting a fuse came my way some time ago when a friend of mine decided to insert a 250mA cartridge fuse in a television line output stage in order to prevent the line output valve from doing a lighthouse act if the grid drive failed. Instead of inserting his fuse in the h.t. positive feed to the line output valve, my friend inserted it in the cathode, which had previously been taken direct to deck. The result was that he lost about 1 to 2kV in e.h.t. and about an inch or so of picture width! But the fuse didn't blow."

Dick frowned.

"That's queer," he remarked. "All I can guess is that the resistance of the fuse provided degeneration in the same manner as does an unbypassed cathode bias resistor in an a.f. amplifier stage."

"That's exactly right," smiled Smithy. "When my friend shorted out the fuse by means of the time-honoured application of a screwdriver, his e.h.t. popped up to normal and the picture expanded to full width."

"Isn't there something else wrong here?" said Dick. "I would have thought that putting a fuse in the cathode circuit of a valve is rather a naughty thing to do, anyway."

"Well, it *is* a little unusual," said the Serviceman, "but only because there are other circuit positions which are more obvious."

But Dick was still not satsified.

"If a fuse in the cathode circuit blows," he continued, "what's to stop that cathode from shooting up to full h.t. potential, whereupon you run the risk of breakdown between heater and cathode?"

"Don't forget," replied Smithy, "that, if the grid remains at chassis potential, an open-circuit cathode cannot rise any higher above chassis potential than by the cut-off voltage for the valve."

There was silence for some moments whilst Dick worked out Smithy's statement. And when he turned to the Serviceman he found that the latter had, craftily, returned to his bench, and was so engrossed in his work that he would answer no further questions whatsoever.







# UNDERSTANDING TELEVISION

PART 22

By **W. G. MORLEY**

*The twenty-second in a series of articles which, starting from first principles, describes the basic theory and practice of television*

The first two articles in this series[1] introduced the principles of deflection and synchronising, in order to explain the manner in which a television signal may be transmitted and reproduced. It was pointed out in these earlier articles that the beam in the receiver cathode ray tube was deflected quickly from left to right and slowly downwards, thereby causing a number of parallel horizontal lines to be traced out on the screen. Whenever the beam had completed its motion to the right it was quickly returned to the left again in order that another line may be traced out. Similarly, when the beam had been deflected sufficiently far downwards it was quickly returned upwards again so that a further cycle of vertical deflection could commence. The earlier articles stated that deflection of the beam from left to right was known as line or horizontal deflection, and that downward deflection was known as frame or vertical deflection. In both line and frame deflection cycles the quick return of the beam was described as the flyback, or retrace.

It was further pointed out, in the first two articles, that, when direct synchronisation is employed at the receiver, the synchronising pulses in the transmitted signal initiate the flyback and enable the receiver deflection circuits to keep in step with those employed at the transmitter.

We shall now commence to examine in detail the deflection circuits in the receiver. In doing so we shall refer to synchronising pulses which may be either positive-going or negative-going. Such synchronising pulses are derived from the transmitted signal with the aid of the *sync separator* stage, the functioning of which will be described in a later article.

### Deflection Circuits

In order that a cathode ray tube may reproduce as a picture the signal passed to its modulating electrode by the receiver, its beam must be deflected both horizontally and vertically. In the case of an electrostatic cathode ray tube this deflection is achieved by applying sawtooth voltages of correct waveform and frequency to its deflection plates, and in the case of an electro-magnetic cathode ray tube by applying sawtooth currents of correct waveform and frequency to its deflector coils. In conventional modern television receivers electromagnetic deflection is invariably used, and the deflection circuits normally take up the appearance illustrated in Fig. 122.

This diagram shows, in block form, the stages which constitute the deflection section

[1] *Understanding Television* 1 and 2. *The Radio Constructor*, Jan. and Feb., 1958.

of the receiver. The line deflection section consists of the line sawtooth generator, the line output valve, and the line output transformer, the latter coupling directly into the line deflector coils. The frame deflection circuits follow the same pattern, the frame sawtooth generator being followed by the frame output valve which, in its turn, is succeeded by the frame output transformer and the frame deflector coils. Both line and frame sawtooth generators are fed with synchronising pulses from the sync separator stage to keep them in step with the transmitted signal.

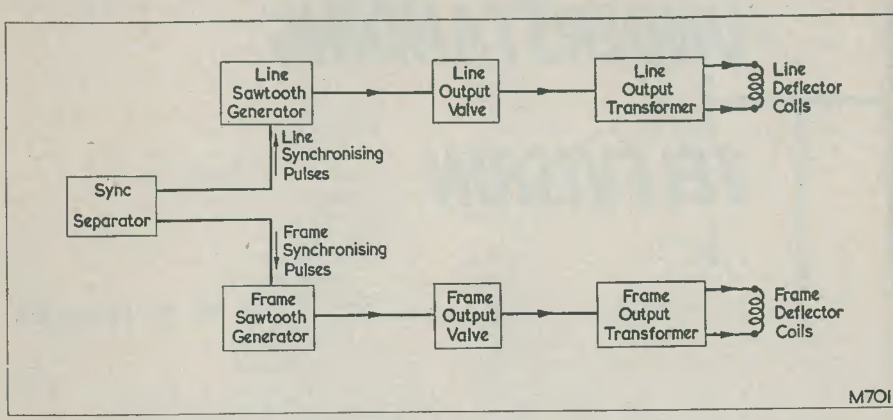



*Fig.* 122. *A block diagram illustrating the various sections in the deflection circuits of a conventional receiver*

Before carrying on further, some points of terminology need to be cleared up. It is usual, in practice, to refer to the sawtooth generators as oscillators, whereupon these become known as *line oscillators* and *frame oscillators*, as applicable. Alternatively, the sawtooth generators may be referred to as *timebases* (qualified by *frame* or *line* as applicable). However, the term timebase may also be used to refer to the composite section provided by an oscillator *and* its output stage.

Synonymous with timebase, and less frequently encountered, are the terms deflection generator and scanning generator.

The block diagram illustrated in Fig. 122 is typical of what is most frequently employed in modern television receivers. Occasionally, by the use of suitable feedback circuits, the line output stage may be made self-oscillatory, whereupon there is no necessity for a separate line oscillator. The frame output stage may similarly be made self-oscillatory, with the result that a separate frame oscillator may also be dispensed with.

**Sawtooth Generators**

Sawtooth generators intended for the line and frame circuits of television receivers may normally be subdivided into two basic parts. One part consists of a "sawtooth-forming circuit," whilst the other consists of an oscillator coupled to that circuit and controlling the time occupied by each part of the sawtooth.

A simple arrangement which demonstrates theoretically the operation of a sawtooth-forming circuit is illustrated in Fig. 123 (*a*). In this diagram we have a condenser connected to a source of h.t. voltage via a resistor. Across the condenser

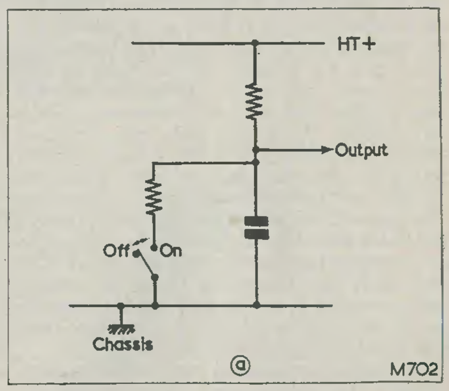



*Fig.* 123 (*a*) *A "sawtooth-forming circuit". The resistor in series with the switch has a much lower resistance than that which couples the upper plate of the condenser to the h.t. positive rail*



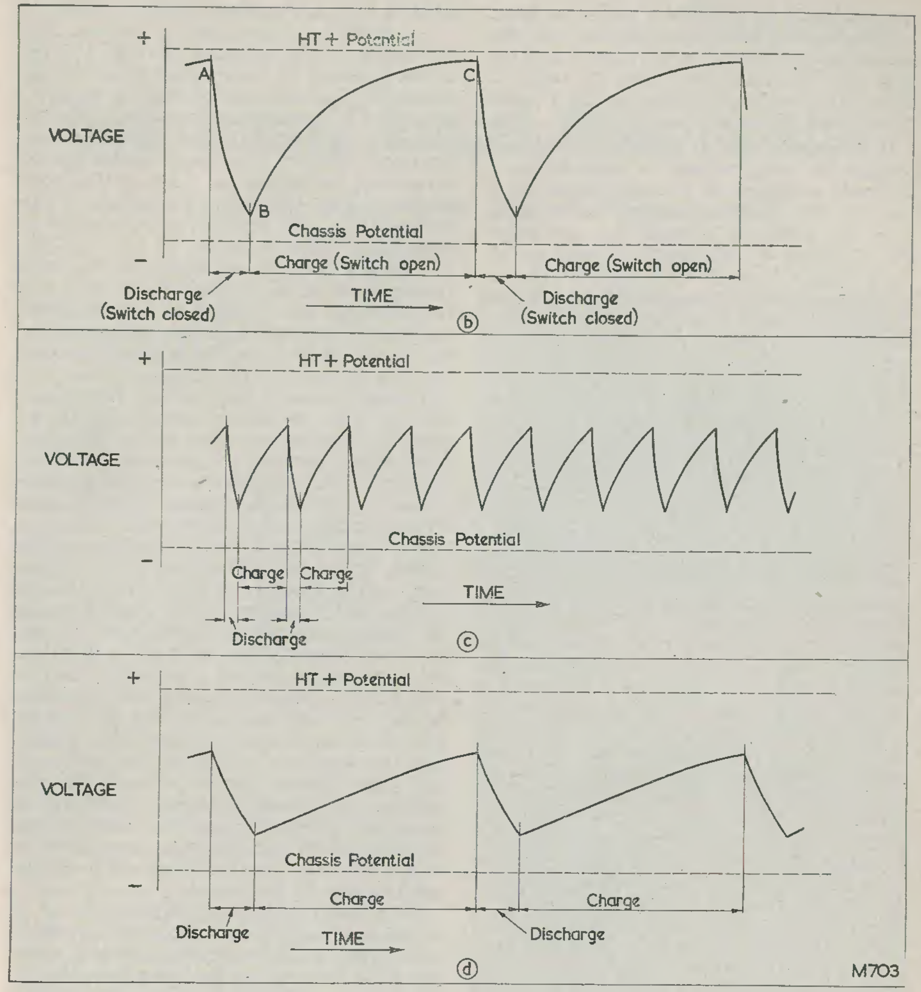



*Fig.* 123 (*b*) *If the switch of the "sawtooth-forming circuit" is repeatedly held closed for a short period of time and open for a long period of time we may obtain the sawtooth waveform shown here. Each section of the sawtooth follows the normal exponential curve given when a condenser charges, or discharges, through a resistor and, because we are allowing the condenser to discharge nearly to chassis potential and to charge nearly to h.t. positive potential, we obtain a sawtooth whose sections are markedly non-linear.* (*c*) *It is possible to obtain a more linear sawtooth by allowing the condenser to charge and discharge over only a part of the exponential curve. In this diagram we have improved linearity by speeding up the switch operation, thereby restricting the range over which the condenser charges and discharges. Apart from the obvious increase in frequency which results, there is also an unavoidable reduction in amplitude.* (*d*) *Another method of improving linearity consists of increasing the value of the condenser, or of increasing the values of the two resistors. By carrying out this change in component values we may retain the original switching frequency whilst still allowing the charge on the condenser to vary over only a part of the exponential curve. Once again, the improvement in linearity is accompanied by a reduction in amplitude* is a switch in series with a second resistor. It is assumed that the resistance of this second resistor is much lower than that of the first, with the result that, when the switch is closed, the condenser discharges much more rapidly than it charges when the switch is open.

If the switch is closed for short periods and opened for long periods we may obtain a sawtooth waveform of the type illustrated in Fig. 123 (*b*). Commencing just before point A in this waveform we have the case where the condenser is very nearly charged to full h.t. voltage. At point A the switch is closed, with the result that the condenser discharges rapidly until point B is reached. At point B the switch is opened again, and we obtain the case where the charge on the condenser rises slowly. This slow rise continues until we close the switch again at point C, whereupon the condenser commences to discharge once more and another cycle is started.

If we examine more closely the production of our sawtooth waveform of Fig. 123 (*b*), several important factors come to light. Firstly, in order to achieve a steady frequency for the sawtooth waveform it is necessary for each successive switching cycle (on and off again) to occupy the same period of time. Secondly, it is necessary for the relationship between the time that the switch is on and the time that the switch is off, *within* the switching cycle, to remain steady if successive sawtooth cycles are to have the same shape.

The sawtooth shown in Fig. 123 (*b*) is not very linear, in so far that the sections representing charge and discharge are markedly curved. When a condenser discharges into a resistor, or is charged via a resistor, the graph representing voltage against time follows what is described as an exponential curve. In Fig. 123 (*b*) the section from A to B, and that from B to C, both trace out part of an exponential curve. Non-linearity in the sawtooth is frequently undesirable, and steps have to be taken to obtain a more linear shape, if only over the period when the condenser is charging. A simple method of doing this consists of restricting the charge and discharge range so that only part of the exponential curve is followed. A typical example is illustrated in Fig. 123 (*c*). In Fig. 123 (*c*) the condenser is not allowed to charge to as high a potential, or to discharge to as low a potential, as it did in Fig. 123 (*b*), with the consequence that we obtain a more linear response, this being especially noticeable for the period when the switch is open. It will be noted that the frequency of the sawtooth waveform of Fig. 123 (*c*) is higher than that of Fig. 123 (*b*), this being due to the fact that the switching cycle must obviously be made shorter if the condenser is to be prevented from charging to too high or too low a potential. Also, the amplitude of the sawtooth is reduced, another inevitable result.

It would be impossible to increase the amplitude of the response of Fig. 123 (*c*) whilst retaining the same linearity (or without increasing the potential of the h.t. supply). We could, nevertheless, revert to our original switching frequency whilst retaining our improved linearity, if we carry out the simple process of increasing the value of the condenser of Fig. 123 (*a*), or the values of the two resistors. The result of such a change in component value is shown in Fig. 123 (*d*). In this last diagram we switch at the same frequency as we did in Fig. 123 (*b*), and, due to the longer time required by the condenser to charge and to discharge, we obtain a waveform which is similar in amplitude and linearity to that of Fig. 123 (*c*).

The sawtooths of Fig. 123 are representative of the waveforms which would be applied to the output valve, line or frame, of a television receiver. The short discharge section of the waveform would then correspond to the flyback period, whilst the long charge section would correspond to the scan period. In a practical arrangement the switch and series resistor of Fig. 123 (*a*) would be replaced by a valve, the anode of which would connect to the upper plate of the condenser, and the cathode to chassis. This valve would then be made conductive (by applying to its grid a potential close to that of its cathode) during the discharge period, and non-conductive (by biasing its grid beyond cut-off) during the charge period. Also, the values of the condenser and the resistor coupling it to the h.t. positive rail would be made such that a sawtooth waveform having the desired linearity, amplitude, frequency, and relationship in time between the charge and discharge sections, would be formed.

In normal television receivers it is a customary requirement that the sawtooth waveform passed to the frame output valve has good linearity in the slow-changing, or scan, section. Present-day line output stages do not normally require a sawtooth input having a linear scan section: indeed, heavy non-linearity is frequently aimed for. Linearity in the fast-changing section of the sawtooth is usually of little importance, as this corresponds to the flyback period.

It is possible for a circuit containing resistance and *inductance* to produce sawtooth waveforms similar to those provided by the resistance and capacity arrangement of Fig. 123 (*a*). In television practice such circuits are employed only in the line output stage; and they will be discussed when we come to deal with this particular part of the receiver.

**Next Month**—In next month's issue we shall examine the functioning of oscillators capable of controlling the "sawtooth-forming circuit."





# Do-it-Yourself Printed Radio Circuits

by Squadron Leader S. W. Sarll, A.M.(Brit.), I.R.E.

### Introduction

1. A printed circuit differs from a conventional wired radio or electronic circuit in that all the electrical interconnections and the component terminations fixing is done by copper sheet conductors bonded to an insulating baseboard (see Fig. 1). Such circuits can be mass-produced to a consistent standard more cheaply than conventional wiring, and the accuracy and long life stability result in a better product. For the aeromodeller, experimenter or amateur who makes printed circuit equipment there are the advantages of reduction in size, ruggedness and simplicity of construction, besides the long life stability. It is now possible to construct a "one-off" circuit at home with no special tools or equipment. Besides radio chassis, printed circuits may be used for rotary or slide switches for actuators, mechanical pulsers and other similar devices.

2. It is not proposed to discuss here the complex equipment used commercially, but to describe a simple though crude way of achieving useful results. Basically the system built around copper-clad laminate board consists of:

(*a*) Painting the required pattern on the copper surface;
(*b*) Etching away the uncovered copper;
(*c*) Removing the protective paint and cleaning the copper;
(*d*) Drilling the connection holes;
(*e*) Soldering the components to the copper conductors.

Anyone capable of handling a paint brush, drill and soldering iron can produce results.

### Drawing

3. Assuming that the required pattern is a radio circuit and that a theoretical diagram is available, the first job is to make an exact full-size drawing on paper of the components and interconnections in their correct place. All components will be anchored by passing their connecting wires through small holes drilled in the baseboard. All interconnections will be by the copper laminate remaining after the surplus is etched away. If absolute miniaturisation is desired, it is a


*Fig.* **1.** *3-transistor receiver on printed panel* help to cut out some card patterns of the profiles of all components and move them around on the board to fit as closely as possible. Positioning of components is critical with some r.f. circuits and must be catered for in the layout drawing. Leave room between fixing holes for a length of lead sufficient to prevent the heat, when soldering the ends, from reaching the components. (See Fig. 2 (a).)

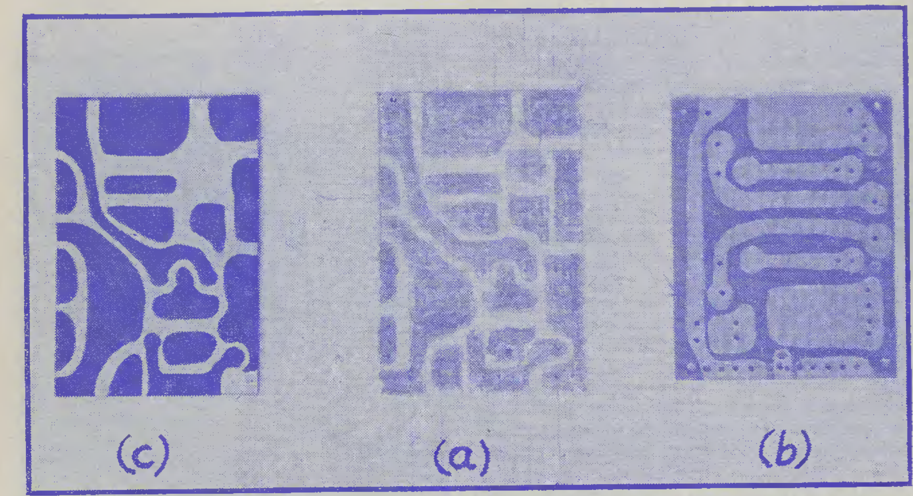



*Fig. 2 (a) Receiver panel pencil sketched; (b) Transistor multi-vibrator panel ready for assembly; (c) Painted ready for etching*

4. Once a satisfactory layout has been drawn, shade in with pencil the areas where the final copper connection is required. One method is to shade as much as possible leaving narrow spaces between the areas to break the continuity where necessary. This method reduces the amount of copper to be removed (less etching solution needed) and leaves a surplus of copper that may be valuable if a circuit change is subsequently necessary. Large unconnected areas can often be made "earthy" by suitable bridges or linking wires. Be satisfied that areas shaded are adequately separated and can be easily copied on the copper by painting.

5. Another method is to draw circular areas around each fixing hole and connect up circles as required by narrow shaded strips. Only the very minimum of copper is left on the board with this method, so it is recommended when the copper is to be subsequently plated (as for switches). For all other applications the first method is recommended.

**Base Material**

6. Many firms are producing good laminate board, but successful results have been achieved using "Formica" Copper Clad Material Engraved DCC.20—0.0028in copper. This material is marketed by Radio and Electronic Products Ltd., 8 Station Parade, Sheen Lane, Mortlake, S.W.14, and pieces can be supplied on order as economical sub-multiples of 12in by 12in. Material with copper deposit on both sides of the insulating board can be obtained for special purposes or very complicated cross circuitry, but is more expensive. Unless considerable heat is applied the 2.8 thou. copper will resist all normal attempts to peel off, but it may be removed quite easily by etching or even by cutting away with a razor blade or modelling knife. A complete kit containing 60 sq. in. of laminated board, chemicals, plastic etching bath, instructions, etc., is obtainable from Proops Bros. Ltd., Dept R, 52 Tottenham Court Road, London, W.1, for 21s.

7. The first job is to cut and sand the board to size, cleaning the cut edge of the copper with a file or sandpaper. Lay the paper pattern exactly over the board and with a sharp point mark the positions of fixing holes and any other significant reference points in the copper surface. Emphasise these points in the copper with a centre punch—do not drill yet.

**Protecting Material**

8. Anything can be used to protect the



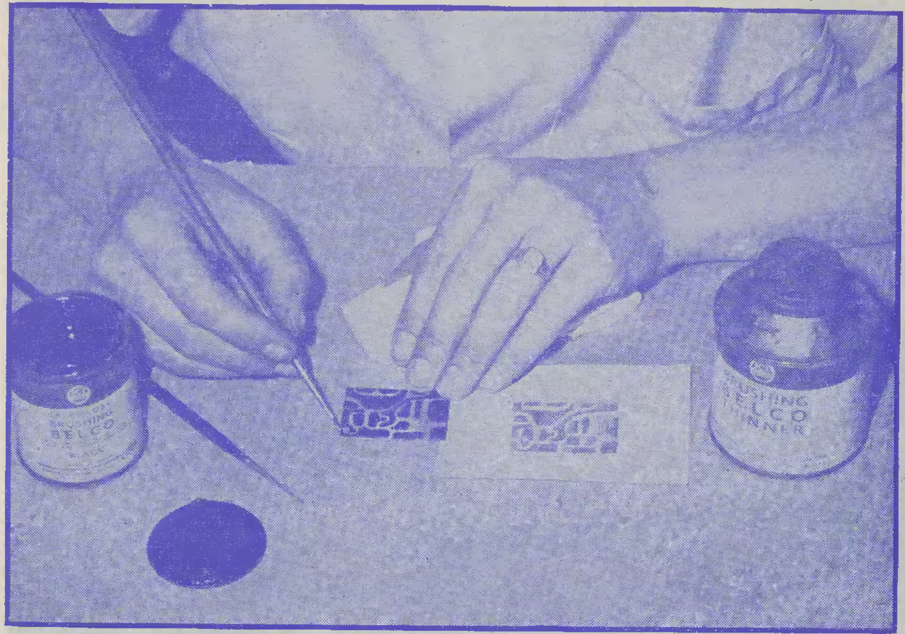


*Fig. 3. Hand painting the copper-clad panel*

*Fig. 4. Etching in a saucer with ferric chloride*

wanted copper that will resist the etching agent. Success has been achieved with:

(*a*) Cellulose enamel;
(*b*) Humbrol enamel;
(*c*) Sellotape;
(*d*) Self-adhesive plastic insulating tape.

Of those tried, cellulose enamel as sold for touching-up cars dries quickest, but even when wet the Humbrol paint resisted the etch (except where handled!). The top layer of Sellotape came loose but the sticky film still gave protection where firmly adhered in the first application.

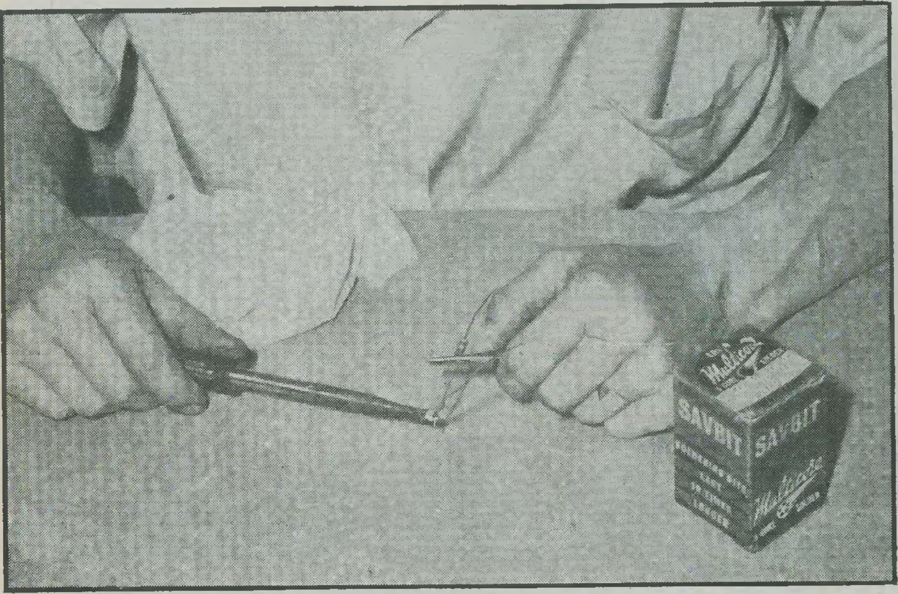



*Fig. 5. Tinning a resistor*

9. Assuming that enamel will be used, it can be applied to the copper by hand, using a fine paint brush. The shaded areas of the paper pattern are copied free-hand on the copper using the hole positions as a guide (see Fig. 3). Ensure that all such positions are well surrounded by paint to allow room on the copper for a good soldered joint. It is not necessary to make a good paint finish, merely cover the areas with sufficient thickness of paint. Straight edges make a better looking job, but provided adequate space is left between areas, it is unnecessary to be too particular. A mistake can be quickly removed and the area repainted. Allow time to dry, or at least to prevent the enamel "running," and the work is ready for etching.

**Etching Material**

10. Satisfactory results have been achieved using ordinary or strong solution of ferric-chloride obtained from any chemists at 1s. to 2s. 6d. per bottle, according to quantity. The solution at the strength supplied, or slightly diluted with water (up to 20%), is poured into a shallow glazed earthenware or china dish, such as a saucer or plate, large enough to accommodate the size of board to be etched. Place the panel in the liquid and allow time for the unprotected copper to be removed (Fig. 4). Keep the liquid in motion with a piece of wood to prevent localised saturation by copper, but take care not to splash the liquid as it is corrosive. About half an hour will be required to remove the spare copper from a small panel, and the liquid may need replacing if it becomes saturated, but don't be impatient. After the first slight change of tone of the copper, success will only be observed by the disappearance of the copper from the edges first. Confirmation that all the spare copper has been removed is obtained by lifting the panel and looking through it at a strong light, when the full translucence of the baseboard will be apparent. Don't leave in the etch beyond this point. Pour the waste liquid away carefully, on waste ground, avoiding other metalwork.



**Cleaning the Work**

11. Both the dish and the board are washed under running water. Paint can now be removed with thinners, dope, or nail varnish remover; it comes off easier if it has not had time to dry really hard. The board is now thoroughly scrubbed under running water, using a mild household abrasive, such as Vim, to produce a bright clean surface (see Fig. 2 (*b*)). Unless it is intended to proceed at once with drilling and assembling, the areas to be soldered should be protected from oxidisation by painting with flux as described below.

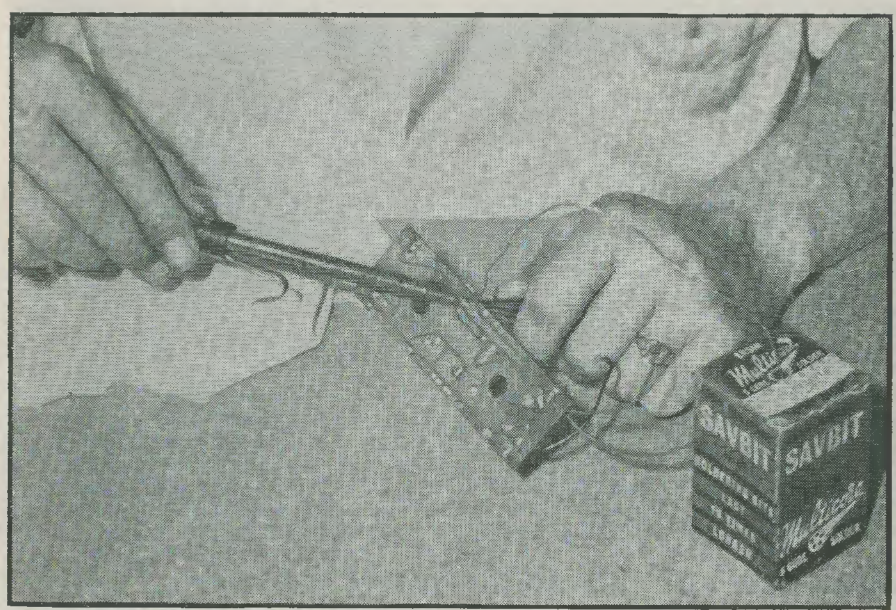



*Fig. 6 Soldering-in a resistor*

**Drilling**

12. All the holes can now be drilled, using a size for component wires that just gives a clearance—too large a hole produces a poor soldered joint. Larger holes for valve bases and parts, etc., can be drilled and cleaned out. Absolute accuracy is unnecessary; "surplus holes" don't matter unless the circuit is completely broken by the hole.

13. The panel should now be thoroughly inspected for good connections where required and absence of unwanted short circuits from faulty etching. A continuity tester is required here.

**Preparing Board and Components**

14. To remove any oxidisation the copper should again be cleaned and scrubbed and then the areas immediately around the holes lightly painted with a very thin film of paste flux. Too much flux will cause a run of solder when connecting and will produce an untidy job. Paste flux is useful here as a liquid flux tends to spread too far.

15. Before use all component wires should be well tinned; dirty or dry wires will not solder easily and excess heat damages the copper bond. Successful wire tinning can be achieved by:

(*a*) dipping in a good liquid flux such as Enthoven Superspeed Liquid Flux;

(*b*) holding the wire at the component end with flat nose pliers to conduct away the excess heat from the component and act as a heat shunt;

(*c*) drawing a clean hot iron downwards from the component end of the wire and off the other end applying the resin-cored solder to the wire at the same time (see Fig. 5).

The blob that forms at the wire end can be cut off before passing the wire through the fixing hole if the wire is left long enough.

16. Remember that a heat shunt is *always* required at the component end of wires when heating. If pliers are not used, ordinary small crocodile clips or sprung Dinkie pin curlers (available from Woolworths), with

heavy copper wire soldered to the ends, may be clipped to the wires. Locking surgical forceps have been found to be ideal for this purpose.

**Fixing and Soldering**

17. Bend the component wires carefully with pliers to allow them to fit easily into the respective fixing holes. If vibration is expected, unequal lengths of wires will reduce resonance effects. Components may be mounted either side of the board, but it is preferable for accessibility to have components on the plain side and solder on the copper side. More rigid construction is achieved by fixing components close up to the board, but better heat insulation when soldering is achieved by having the components well "stood-off" if space and vibration are not critical. A small loop may be formed in the wire close to the component before it passes through the panel, so increasing the heat path to the component yet allowing the wire to be firmly held against the board. All components can be fitted to the panel, the wire ends turned to lie along the copper, and the layout "proved" before soldering.

18. To solder, use a low wattage iron with a small clean hot bit. The Adcola 25 watt or Henley instrument types are suitable. Large electrician's or gas heated irons are useless for printed circuits (except in expert mass production hands) and so also are dirty, corroded or "lukewarm" bits. The thin (22 s.w.g.) Ersin Savbit Multicore solder is better than the larger size for printed circuit soldering as the quantity per joint can be more carefully controlled. 18 s.w.g. Ersin or Enthoven solder is satisfactory but thicker gauge solder is difficult to control.

19. Apply a heat shunt to each wire before soldering—this is particularly important for transistor wires—and apply the soldering iron tinned surface to the copper adjacent to the wire and apply the resin-cored solder at the same time to both copper and wire (Fig. 6). If maximum heat is applied to the copper and less to the wire, the solder will quickly run to form a small bright blob around the wire. Both iron and solder should be removed as soon as the wire has been completely encircled since excess heat or solder does no good at all.

20. Inspect all joints for faulty or inadequate bonds, then snip off the excess wires and the job is done. No additional protection for the joints or copper is really needed.

21. If sufficient copper has been left on the board, a circuit change can be subsequently effected by isolating a piece of copper with a razor blade, drilling new holes and linking the two areas concerned with a piece of tinned wire as if it were a component.

## Can Anyone Help?

*Requests for data are inserted free of charge. Enquirers undertake to answer all correspondence and defray all expenses*

**R3121 Receiver.**—M. Higginson, 8 Buckingham Road, Bicester, Oxon, would like to borrow or purchase a service sheet on this receiver.

**R1475 Receiver.**—H. S. Griffiths, 10 Parkview, Legsby, Market Rasen, Lincs, requires a service sheet or manual of this equipment, especially in relation to the "guard" channel and type of crystal used.

**Champion "Planet" Receiver.**—F. H. Holdsworth, 29A Alexandra Drive, Gypsy Hill, London, S.E.19, wishes to borrow or purchase a service sheet for this five-valve a.c./d.c. receiver.

**"The Radio Constructor."**—A. G. Nicholl, Byard House, Stamford, Lincs, would like to purchase the November 1956, January and February 1957 issues of the magazine.

**CR100 Receiver.**—G. Coombe, 45 Saxon Road, Exeter, Devon, wishes to buy or borrow the circuit, manual, etc.

## R.A.E. and Morse classes

Grafton Radio Society (G3AFT) announce that 72 attended the first three evenings of their well-known R.A.E. and Morse classes. As 41 attended on the Monday evening, they regret that no more applicants can be considered for that evening, but there are a few vacancies for the Tuesday and Wednesday repeat lectures which are held at Montem School (Room 35), Hornsey Road, Holloway, London, N.7 (R.A.E. 7-9 p.m.; Morse 9-10 p.m.). In addition to the above, the usual club meetings are held every Friday evening, 8-10 p.m., to which new members and visitors are indeed welcome.

**ERRATA**

In the article entitled "A Guitar Amplifier" in the last issue an error occured in the Inverse Feedback diagram on page 201. The 500kΩ grid leak should have been returned to the 10kΩ resistor side of the 0.5μF condenser and not to the top side as shown.





# On Buying an HRO Receiver

By L. H. Rouse and J. B. Dance, M.Sc.

THE HRO RECEIVER HAS BEEN ON SALE ON the surplus market for many years; whilst its performance is undoubtedly surpassed by modern equipment, it is nevertheless a very good general coverage receiver and is deservedly popular with transmitting amateurs and short wave listeners. At the present time the HRO may be obtained in London for amounts varying between about £15 and £23, depending on the condition of the receiver and the number of coil units supplied. The cost of packing and postage on the receiver is well over £1 and it is therefore worthwhile contemplating a journey of reasonable length to fetch it, especially as one then has the chance to pick and choose from a large number of receivers.

The receiver has plug-in coils and this is often considered to be its greatest drawback. It must be remembered, however, that the coils are totally enclosed in metal and all of the coils for any one desired frequency range are plugged into the front of the receiver as one unit. Nine coil units were supplied with the receiver obtained by one of the authors (an HRO Senior with a crystal filter unit), but it is possible to obtain extra bandspread coil units. As each coil unit has measurements of about 10in x 4in x 2½in, it can be seen that the coils consume much space and it is highly desirable that they should be housed in a suitable cabinet. The receiver covers from 50 kc/s to 30 Mc/s in the nine ranges—an exceptionally wide coverage.

The i.f. is that which is commonly used in American receivers, that is 456 kc/s. This gives reasonable selectivity, but the selectivity could be very much improved by the addition of a second intermediate frequency unit operating at about 50 to 100 kc/s (see July 1959 article in *Practical Wireless* by one of the authors). The HRO does suffer slightly from second channel interference in the 10-metre amateur band because of the comparatively low intermediate frequency and even the use of the two r.f. stages does not completely prevent this type of interference. Considerable modifications would have to be carried out to eliminate it, such as adding a preselector or tapping down some of the r.f. coils.

The mutual conductance of the 6D6 valves used in the r.f. stages is comparatively small and therefore the signal-to-noise ratio of the HRO between about 15 and 30 Mc/s is not as good as that of a good modern receiver. Methods have been described (for example in the February 1949 edition of *QST*) whereby the signal-to-noise ratio of the HRO may be increased by the use of modern miniature valves in the early stages of the receiver, but such methods involve considerable redesign and rebuilding. It is very doubtful if many people who have recently paid £20 or so for an HRO will wish to strip down a large part of it. The modifications described in this article are of an extremely simple type, require practically no thought whatsoever, and may therefore be easily carried out by the novice.

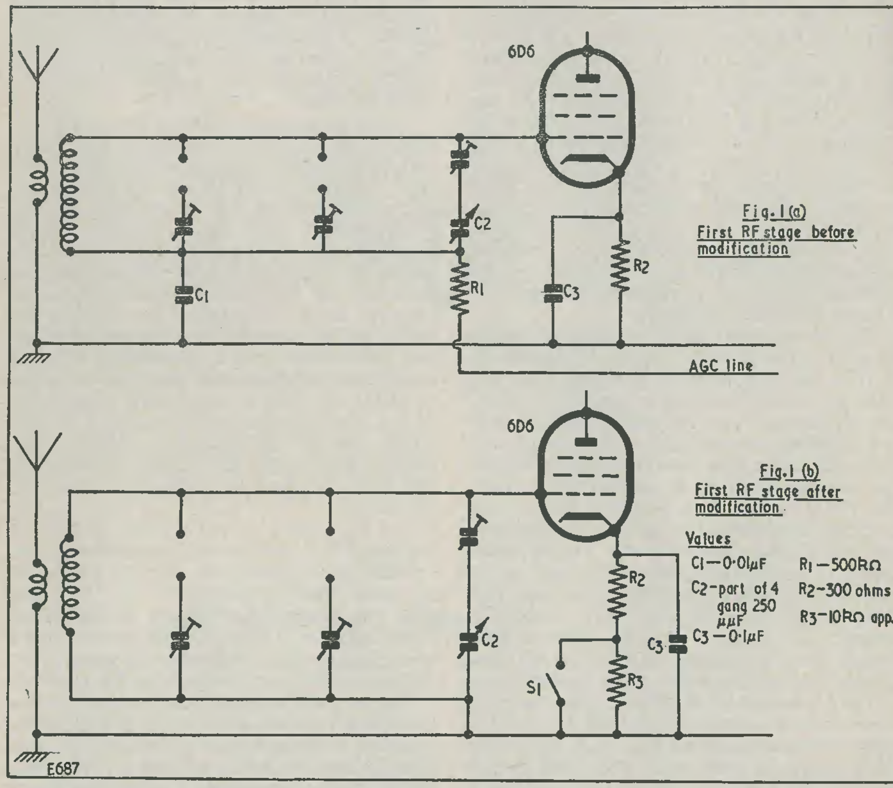
The "S" meter in the receiver purchased did not give suitable readings and the reason for this was found to be that the final 6D6 i.f. valve which helps control the "S" meter was not performing within its published characteristics. The 6D6 valves were changed about to provide a temporary solution to the problem until a new valve could be obtained.

The gain of the receiver can be considerably increased by reducing the value of the biasing resistor in the cathode circuit of the final intermediate frequency amplifier. The value of this resistor supplied in most receivers is between 1,000 and 5,000 ohms, but it can be conveniently reduced to about 300 ohms. Besides improving the performance of the receiver, the increased gain makes the "S" meter readings much more satisfactory.

The automatic gain control (a.g.c.) of the receiver is connected to both the first and the second r.f. stages and also to both of the i.f. stages of the HRO. Although the a.g.c. action is improved by applying a.g.c. to the first r.f. stage, the signal-to-noise ratio on high frequencies is reduced. This is because the a.g.c. bias reduces the mutual conductance and therefore the gain of the first r.f. stage. This allows the noise generated in the input circuit of the receiver to become more important on high frequencies where the noise from the aerial is small. The receiver signal-to-noise ratio on high frequencies can therefore be improved by removing the 500kΩ resistor ($R_1$ in Fig. 1 (*a*)) connecting the a.g.c. line to the first r.f. valve of the receiver. The bottom of the tuned circuit must then be earthed as shown in Fig. 1 (*b*). The 0.01μF condenser ($C_1$) may be completely removed.

switching in the additional resistor, $R_3$ in Fig. 1 (*b*) between the cathode resistor of the r.f. valve and earth for use only when powerful signals are being received. The value of this resistor may be between 500Ω and 30kΩ and should preferably be chosen to obtain the desired results when powerful stations are being received. A potentiometer could be used instead of this switched resistor, but if the potentiometer is not returned to zero for reception of all but the most powerful signals, then the "S" meter readings and signal-to-noise ratio would be affected. It is generally easier to remember to return the switch than it is to return a potentiometer to zero. The additional resistor should be shorted out by the switch $S_1$ when any signals other than very powerful ones are being received.

Further improvement of the signal-to-noise ratio may be obtained by replacing the




If the a.g.c. line is disconnected from the first r.f. stage as suggested, however, overloading and distortion may occur when powerful stations are being received. This trouble may be completely avoided by

first r.f. valve by one which has a higher mutual conductance; this will almost certainly require altering the valve base connections and receiver alignment, however, and may cause oscillation. The use of an 1851



instead of the 6D6 has been suggested (see *QST*, February 1949). Care should be taken to choose a valve which does not load the tuned circuits too much or greater second channel interference will be experienced. The addition of a preselector would probably be a better solution to the problem of obtaining better signal-to-noise ratio and good second channel rejection.

It is necessary to adjust the control of the HRO marked "r.f. gain" before using the "S" meter readings. This control is easily knocked accidentally by the hand after the adjustment has been made and the "S" meter readings are then meaningless. The panel of the HRO was therefore drilled so that a small metal clamping device could be used on the metal circle attached to the r.f. gain control and the setting could then be maintained. This makes the "S" meter much more convenient to use.

No noise limiter is present in the HRO and this is a great disadvantage when the receiver is used at high frequencies. It is preferable not to have to punch holes in the chassis in order to add a noise limiter valve and i.f. noise silencing circuits were not therefore used, although they can give better results than an audio limiter. A germanium diode was tried at first in an audio limiter shunt circuit, but its forward resistance was high enough to prevent it from being really effective. In order to avoid chassis drilling an EA76 sub-miniature diode was used, as this has connecting wires coming directly out of the glass; it should be clipped to the chassis. A possible alternative (if there is enough space available) is the VR92 which is easily obtainable on the surplus market. The audio noise limiter "chops off the tops" of the noise peaks and considerably improves performance in noisy localities. The limiter circuit is conveniently placed between the detector and the input to the 42 output valve. The potentiometer to set the threshold at which the limiter begins to operate was fitted to a hole drilled in the front panel on the same level and to the right of the "S" meter on/off switch.

The HRO is certainly an excellent bargain and it is very doubtful whether its performance can be surpassed by any receiver within the same price range; it is probably the cheapest receiver approaching real communications standards available.

Next Month . . . HRO ALIGNMENT DATA

# RADIO HOBBIES EXHIBITION

## Royal Horticultural Old Hall, Vincent Square, London, S.W.1.

## 25th to 28th NOVEMBER, 1959

*List of Exhibitors*

| | *Stand Nos.* |
|---|---|
| A.P.T. Electronics Ltd. | 8 |
| Avo Ltd. | 22 |
| British Amateur Television Club | 1A |
| Collins Radio Co. (of England) Ltd. | 17 |
| Data Publications Ltd. *(The Radio Constuctor)* | 24 |
| Daystrom Ltd. (Heathkits) | 18 |
| Enthoven Solders Ltd. | 10 |
| *Hi-Fi News* | 26 |
| Home Radio (Mitcham) Ltd. | 15/16 |
| Iliffe Press Ltd. (*Wireless World*, *Electronic and Radio Engineer*) | 9 |
| Jason Motor and Electronic Co. | 14 |
| K.W. Electronics Ltd. | 13 |
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| Mayra Electronics Ltd. | 32/33 |
| Norman Price (Publishers) Ltd. | 5 |
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# The "Different" Hi-Fi Unit

By R. S. SQUIRES

The "different" hi-fi unit was designed and constructed to fulfil these specific requirements. They were:

(1) To provide a reasonable output stage for an old radiogram which had been modified to take a four-speed auto-changer.
(2) To save the expense involved by the addition of a push-pull output stage.
(3) As an experimental project.

The extra components required are:
One double-pole switch (rotary type);
Two type 6BW6 valves (and valve-holders);
One loudspeaker with matching transformer;
Two, perhaps three, potentiometers;
One 8μF condenser; and
Sundry resistors and condensers.

The whole fits quite comfortably into a chassis measuring approx. 5in x 4in with a depth of 2in.

### The Circuit

A glance at the circuit diagram will show that the unit consists basically of two single-ended output stages, driven from a common stage: the original a.f. output valve of the receiver to which the Hi-Fi unit is to be added.

Volume control is provided by $VR_1$ and input is selected by $SW_1$. The other half of the switch can be used to break the h.t. supply to the receiver-unit when the auto-changer is in use.

The actual configuration of "$V_4$" will depend on the constructor's requirements, "$V_4$" being the last stage in a conventional superhet circuit with single-ended output. It should be a fairly simple matter, though, to arrange the output stage of any receiver to conform approximately to the circuit given.

The output transformer in the original circuit has been replaced by $R_1$. If a pentode valve is used then a value of about 250kΩ should suffice for this resistor, as what was previously a current amplifier now has to be converted to a voltage amplifier—without causing distortion of the input signal! Experiment, no doubt, will yield the best value.

From $V_4$ anode the amplified signal is passed to $C_1$ and $C_2$ (these should be good quality components of the values indicated) and thence to the control grids of $V_1$ and $V_2$, via gain controls $VR_2$ and $VR_3$.

The high frequency component only of the signal is fed to the grid of $V_2$, due to the greater reactance to lower frequencies of $C_2$. Hence a considerable control is possible over the "high" end of the audio spectrum reaching $V_2$.

All signal frequencies are passed to the grid of $V_1$, via $C_1$ and $VR_2$, but the high frequency component is eliminated, after amplification, by the low reactance to them provided by $C_3$. $VR_2$ controls the gain of $V_1$ and hence the low-frequency response of the unit. Therefore, the whole of the response characteristic can be adjusted to the listener's choice. The unit can, of course, be constructed simply as a Hi-Fi unit for use with crystal pick-ups, and be fitted into a portable record reproducer or similar system. "$V_4$" could then be a 6J7 and component values for this particular arrangement have been given.

*Note:* It should, of course, be ascertained that the receiver can supply the additional currents required by the output valves, both h.t. and l.t. Should it prove incapable of doing so, then a separate power supply, and a larger chassis, will be required. In this connection, it should be remembered that replacing the existing output valve by a type such as the 6J7 will result in a reduction of the h.t. current needed by the receiver itself.

### Construction

The original unit was made, as has been mentioned, on an aluminium chassis measuring 4in x 5in x 2in. A 12-way tag-strip was mounted down the centre of the chassis, with the valves on either side: $VR_2$ and $VR_3$ were also mounted in the chassis both on the same side, and the whole unit was screwed into the cabinet by means of woodscrews passing through the chassis flanges into the front panel. $VR_1$ was left in its original position, though its value may need to be changed to suit the crystal input. Layout is not critical; but grid leads should be kept short and screened if they exceed an inch or so.

The switch marked $SW_1$ was a rotary switch supplied by Bulgin Ltd., and was used, in the original unit, to break the h.t. supply to the radio tuner unit when the gram was in use. It also switched the input to the volume control from "radio" to "gram." The former function, however, is not really necessary, though a large signal appearing on the output of the receiver detector may well be coupled by "stray" effects into the input of the voltage amplifier stage.

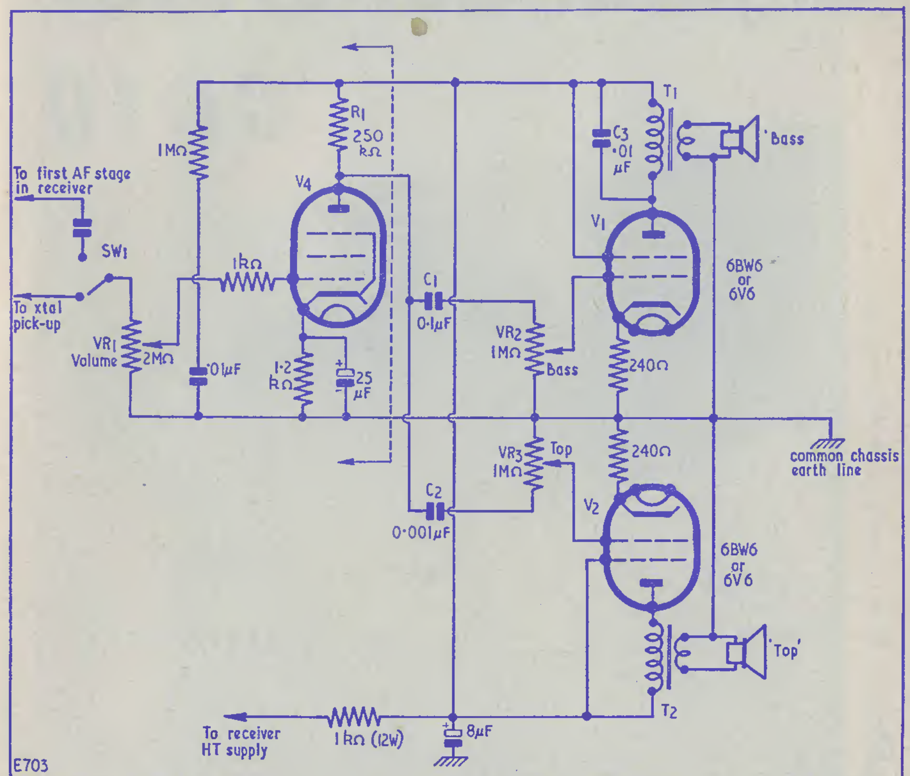
The switch can be mounted in any convenient place. Grid leads should be kept short though, and it should not be adjacent to any wiring carrying mains or h.t.

### Speaker Phasing

When the whole has been completed, and a place found for the extra speaker and its transformer, the speakers must be correctly "phased." This is best done with a torch battery connected in turn to the *primary* of the output transformers. With the unit disconnected from the supply, of course, connect the +ve side of the battery to the h.t. end of the transformer primary and the other terminal to the valve end of the primary. Note which way the loudspeaker cone "jumps" when contact is made and alter one transformer, if required, to make the cones move in the same direction when the process is repeated on the other output transformer.

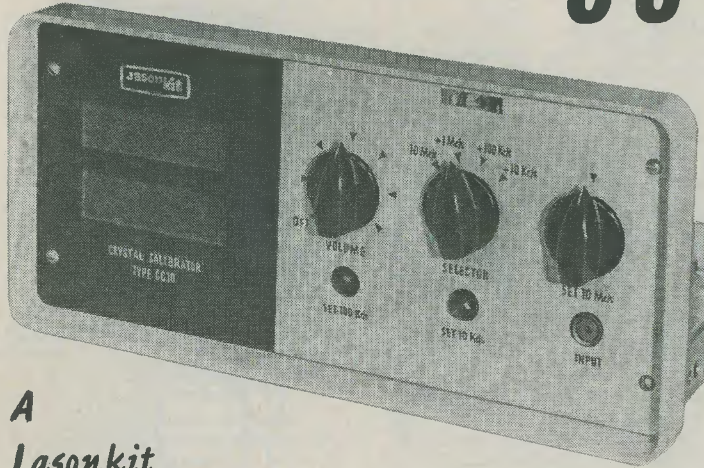
### Results Obtained

The results obtained from the above system are quite satisfactory and compare favourably with the inexpensive class of Hi-Fi equipment.




*Circuit of the "Different" Hi-Fi Unit. Apart from $SW_1$ and $VR_1$, all components to the left of the dotted line would have the original circuit values. $R_1$ replaces the original output transformer, and the values given here are those required when a 6J7 is substituted for the original output valve. This arrangement would also be used if the unit is constructed purely as a Hi-Fi amplifier*

# Crystal Calibrator CC10




*A Jasonkit Design*

by G. BLUNDELL

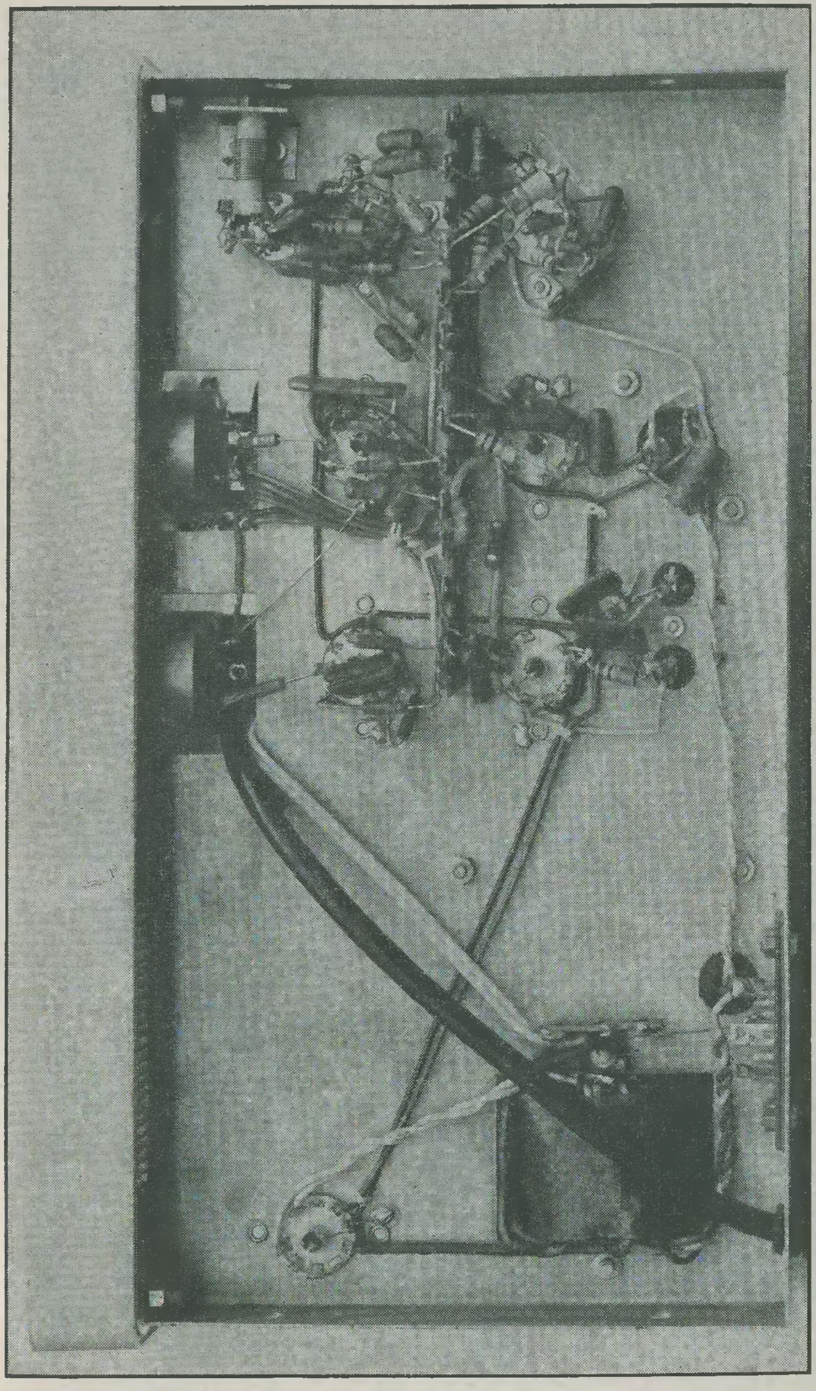
A CRYSTAL CONTROLLED CALIBRATOR OF the type about to be described provides one of the most accurate methods of r.f. generator calibration available. The maximum accuracy which can be attained is ultimately governed by the frequency stability of the B.B.C. standard transmissions. Generators covering a frequency band of from 10 kc/s to some hundreds of megacycles can conveniently be checked.

Essentially, the CC.10 consists of a master crystal-controlled 1 Mc/s oscillator with 10 kc/s and 100 kc/s multivibrators synchronised to it. The output of these three oscillators is passed through a squarer providing a large number of harmonics into a mixer stage. This signal is combined with a further local 10 Mc/s oscillator and the signal from the generator under test. The resulting mixture is fed to an audio stage feeding an internal speaker. There is, therefore, a zero beat whenever the generator signal is such that it is an exact multiple of one of the internally generated harmonics.

Referring now to the circuit diagram, it will be seen that the crystal oscillator stage $V_3$ consists of an EF80 valve connected as a modified Colpitts oscillator. This circuit scores over the more common type of crystal oscillator in the extremely good frequency stability with h.t. supply variation, and in that no critical component values are necessary. In fact, changes of up to 20% in the h.t. rail have little effect on the frequency. Normally the oscillator frequency will be within 0.01% of the nominal value, but greater accuracy may be achieved if it is varied slightly by means of the trimmer, $TC_1$. The procedure to be followed is described in the paragraph on testing procedure.

$V_2$ (ECC81) is a symmetrical multivibrator which is free-running at a frequency of approximately 100 kc/s. This frequency is determined by the time constants of the cross-coupling condensers ($C_5$ and $C_6$) and the grid leaks ($R_9$, $R_6$ and $VR_2$). $VR_2$ is included in the frequency determining





*Showing clean layout underneath—compare with Fig. 2*

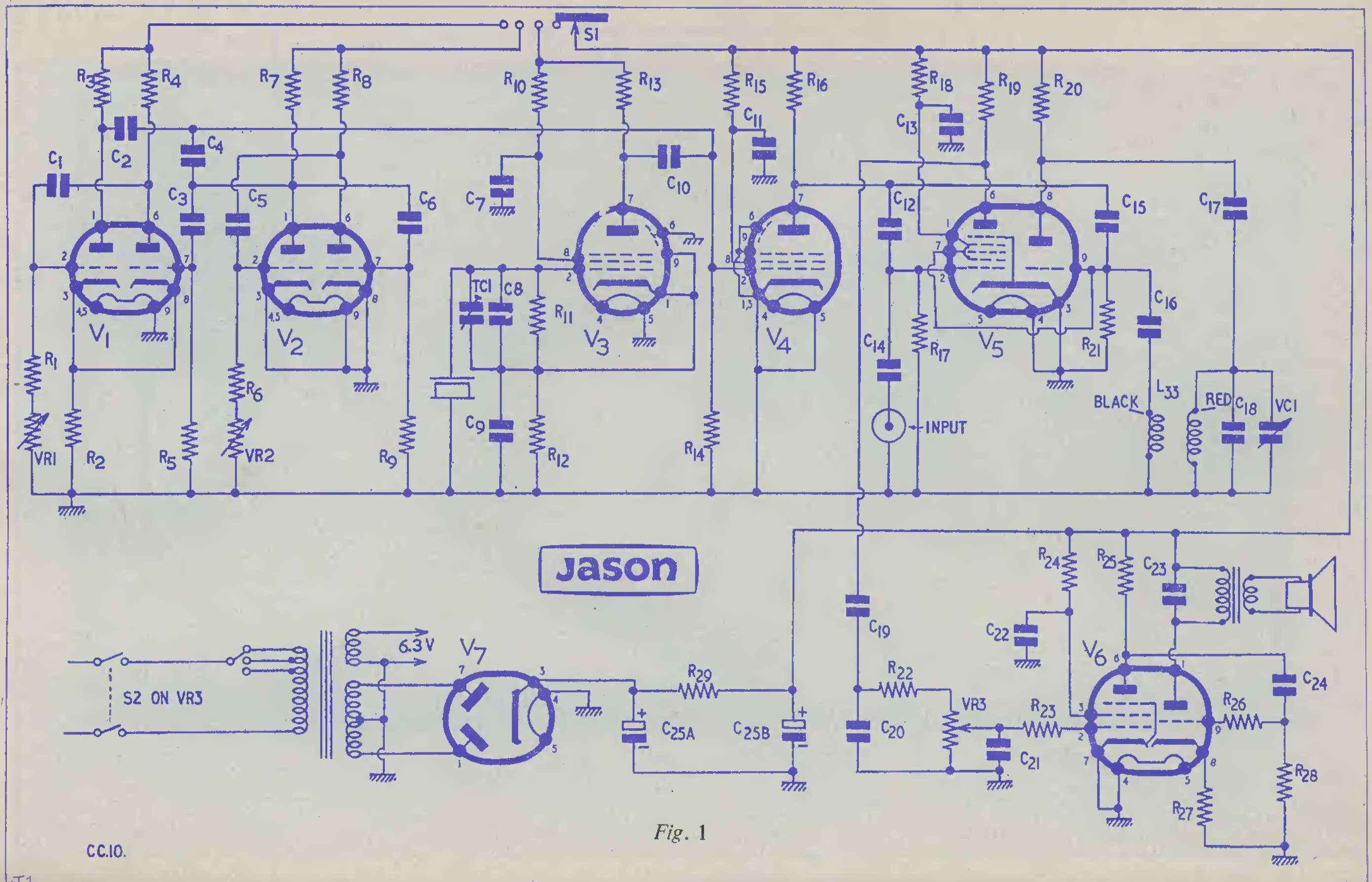



*Fig. 1*

circuits to enable small frequency changes to be made. A synchronising signal is taken from the output of $V_3$ (the crystal oscillator) and fed through $C_4$ to one of the double triode anodes. This condenser serves a double purpose in that the multivibrator output signal also passes through it and combines with the output of $V_2$ at the grid of $V_4$ (EF80).

The 10 kc/s multivibrator $V_1$ (ECC81) is of the asymmetrical cathode-coupled type. The main frequency determining components in this case are the coupling condenser $C_1$ together with $R_1$, $VR_1$; the provision of $VR_1$ again enables small frequency shifts to be made. Synchronising signals are taken from the output of the 100 kc/s multivibrator through $C_3$ to the remaining free grid. The output is taken from an anode through $C_2$ to the grid of $V_4$. This stage is

## COMPONENTS LIST

### FOR THE JASON CRYSTAL CONTROLLED CALIBRATOR CC.10

*Set out for easy reference to theoretical diagram above*

*Resistors*

| | |
|---|---|
| $R_1$ | 33kΩ ½W 20% carbon |
| $R_2$ | 2.2kΩ ½W 5% high stability |
| $R_3$ | 22kΩ ½W 20% carbon |
| $R_4$ | 22kΩ ½W 20% carbon |
| $R_5$ | 1kΩ ½W 20% carbon |
| $R_6$ | 15kΩ ½W 20% carbon |
| $R_7$ | 22kΩ ½W 20% carbon |
| $R_8$ | 22kΩ ½W 20% carbon |
| $R_9$ | 15kΩ ½W 20% carbon |
| $R_{10}$ | 100kΩ ½W 20% carbon |
| $R_{11}$ | 470kΩ ½W 20% carbon |
| $R_{12}$ | 10kΩ ½W 20% carbon |
| $R_{13}$ | 22kΩ ½W 20% carbon |
| $R_{14}$ | 470kΩ ½W 20% carbon |
| $R_{15}$ | 10kΩ ½W 20% carbon |
| $R_{16}$ | 10kΩ ½W 20% carbon |
| $R_{17}$ | 1MΩ ½W 20% carbon |
| $R_{18}$ | 100kΩ ½W 20% carbon |
| $R_{19}$ | 220kΩ ½W 5% high stability |
| $R_{20}$ | 33kΩ ½W 20% carbon |
| $R_{21}$ | 47kΩ ½W 20% carbon |
| $R_{22}$ | 47kΩ ½W 20% carbon |
| $R_{23}$ | 10kΩ ½W 20% carbon |
| $R_{24}$ | 1MΩ ½W 20% carbon |
| $R_{25}$ | 220kΩ ½W 20% carbon |
| $R_{26}$ | 10kΩ ½W 20% carbon |
| $R_{27}$ | 470Ω ½W 20% carbon |
| $R_{28}$ | 470kΩ ½W 20% carbon |
| $R_{29}$ | 2kΩ 3W 10% w.w. |

*Condensers*

| | |
|---|---|
| $C_1$ | 500pF 2% silver mica |
| $C_2$ | 3.3pF ceramic |
| $C_3$ | 5pF ceramic |
| $C_4$ | 3.3pF ceramic |
| $C_5$ | 100pF 10% silver mica |
| $C_6$ | 100pF 10% silver mica |
| $C_7$ | 5,000pF ceramic |
| $C_8$ | 33pF 10% silver mica |
| $C_9$ | 150pF 10% silver mica |
| $C_{10}$ | 500pF ceramic |
| $C_{11}$ | 5,000pF ceramic |
| $C_{12}$ | 5pF ceramic |
| $C_{13}$ | 5,000pF ceramic |
| $C_{14}$ | 5pF ceramic |
| $C_{15}$ | 3.3pF ceramic |
| $C_{16}$ | 100pF 10% silver mica |
| $C_{17}$ | 5,000pF ceramic |
| $C_{18}$ | 100pF 10% silver mica |
| $C_{19}$ | 5,000pF ceramic |
| $C_{20}$ | 500pF ceramic |
| $C_{21}$ | 500pF ceramic |
| $C_{22}$ | 5,000pF ceramic |
| $C_{23}$ | 5,000pF ceramic |
| $C_{24}$ | 5,000pF ceramic |
| $C_{25}$ | 50+50μF 275V wkg. |

*Valves*

| | |
|---|---|
| $V_1$ | ECC81 |
| $V_2$ | ECC81 |
| $V_3$ | EF80 |
| $V_4$ | EF80 |
| $V_5$ | ECH81 |
| $V_6$ | ECF80 |
| $V_7$ | EZ80 |

*Potentiometers*

| | |
|---|---|
| $VR_1$ | 100kΩ linear preset pot. |
| $VR_2$ | 10kΩ linear preset pot. |
| $VR_3$ | 250kΩ log. pot. with switch |

*Miscellaneous*

| | |
|---|---|
| $TC_1$ | 3–15pF variable air spaced trimmer, Jason type CT2 |
| $TC_2$ | 1–15pF variable air spaced trimmer, Jason type CV8 |
| $S_1$ | Jason switch type No. S112 |

Mains transformer, Jason type No. MT51
Output transformer, Jason type No. OT4
Oscillator coil, Jason type No. L33
Loudspeaker, Jason type No. Z155
1 Mc/s crystal, Jason type No. Z130

operated with zero bias and acts as a limiter, with the result that the sine wave input is amplified and converted to an approximation of a square wave with its large number of harmonics of the original fundamental frequency. This composite signal is fed through $C_{12}$ to the grid of $V_5$ (ECH81), which in some respects operates in a similar fashion to the frequency changer in a superhet receiver.

In place, however, of the usual variable frequency local oscillator there is a fixed frequency oscillator running at 10 Mc/s. This is a conventional tuned anode circuit utilising the triode of the ECH81 as the oscillator valve. An unusual part of the circuit is the provision of $C_{15}$, which makes it possible to lock the 10 Mc/s oscillator to the 1 Mc/s standard.

However, instead of the usual intermediate frequency which is obtained from the mixer in a superhet receiver, the output in this case consists of audio frequency signals derived from the frequency difference between the "aerial signal" from a signal generator under test fed into the ECH81 grid and a harmonic of one of the internally generated frequencies.

This audio signal is fed to an audio amplifier $V_6$, consisting of an ECF80 valve. The only requirement of this stage is high sensitivity together with stability, and this is achieved at the cost of a limited frequency response and a fairly high level of distortion. The pentode portion of the ECF80 acts as a high gain voltage amplifier feeding the triode acting as a power amplifier giving a power output of about $\frac{1}{2}$ watt. The high note response is purposely limited to prevent instability and the low note response to reduce microphony.

At this stage, the operation of $S_1$ requires some explanation. It will be seen that the h.t. supplies of $V_1$, $V_2$ and $V_3$ are taken through this switch with the result that the 10 Mc/s oscillator is the only one which is always operating. On turning the switch from the position shown on the circuit diagram to the next position, h.t. will become available to $V_3$ the 1 Mc/s oscillator. The 10 Mc/s oscillator which so far has been free running will lock and run in synchronisation. On turning the switch to the next position, the 100 kc/s multivibrator will be brought into operation and finally the 10 kc/s multivibrator will be switched on. This allows easy identification of the various harmonics, but this will become more apparent on reading the paragraph on operating instructions.

**Assembly Notes**

The assembly follows normal practice for fixing valveholders, tagstrips, etc., the details being given on Figs. 2 to 4, and only a few points require explanation.

(*a*) $\frac{3}{16}$in long 6BA screws are used for fixing the two preset type potentiometers. These screws must not be longer because they would lock the potentiometer centres.

(*b*) The co-axial output socket is spaced away from the front panel with two 4BA nuts which fit loosely over the 6BA fixing screws.

(*c*) The two valve retainer clips are used for holding the crystal firmly in place. They should be pushed through the small holes at the sides of the crystal holder and clipped over the body of the crystal.

(*d*) The fixing of the frame surround casting is best left until wiring is complete, when it can be screwed to the chassis with 4BA screws through the recessed holes at each corner of the casting. 4BA spring nuts can then be slipped over the appropriate drilled thin flanges to correspond with the fixing holes on the scale.

(*e*) The cover is fitted into the slot running round the rear of the casting and screwed to the 4BA hank bushes on the sides of the chassis. The base and back are screwed into place with self-tapping screws after the cover has been fixed in position.

**Wiring Notes**

(*a*) The components shown on the wiring diagrams Figs. 2, 3 and 4 are not necessarily drawn to scale, but indicate the connection and appropriate position taken up by each component.

(*b*) The wiring diagrams should be followed during assembly but to gain familiarity with the instrument it should, at every stage of the assembly, be compared with the circuit diagram.

(*c*) Wires and component leads should be pushed through and wrapped around tags and valveholder pins to ensure a firm mechanical connection. No tag or valveholder pin should be soldered until all the leads and components on that particular tag are in place and have been checked.

(*d*) Connecting wires should be straight with sharp distinct bends and be run flat touching the chassis.

**Wiring Procedure**

(*a*) Earth the centre spigot and appropriate pins on each valveholder to a soldering tag, as shown on Fig. 2.

(*b*) The wire connections are best made before the actual components are wired in place. Leads running from the underside to the top of the chassis are lettered on the diagrams to facilitate tracing.

(*c*) The remaining resistors and condensers can now be wired in place.

**Testing Procedure**

(*a*) Check all wiring thoroughly. Time



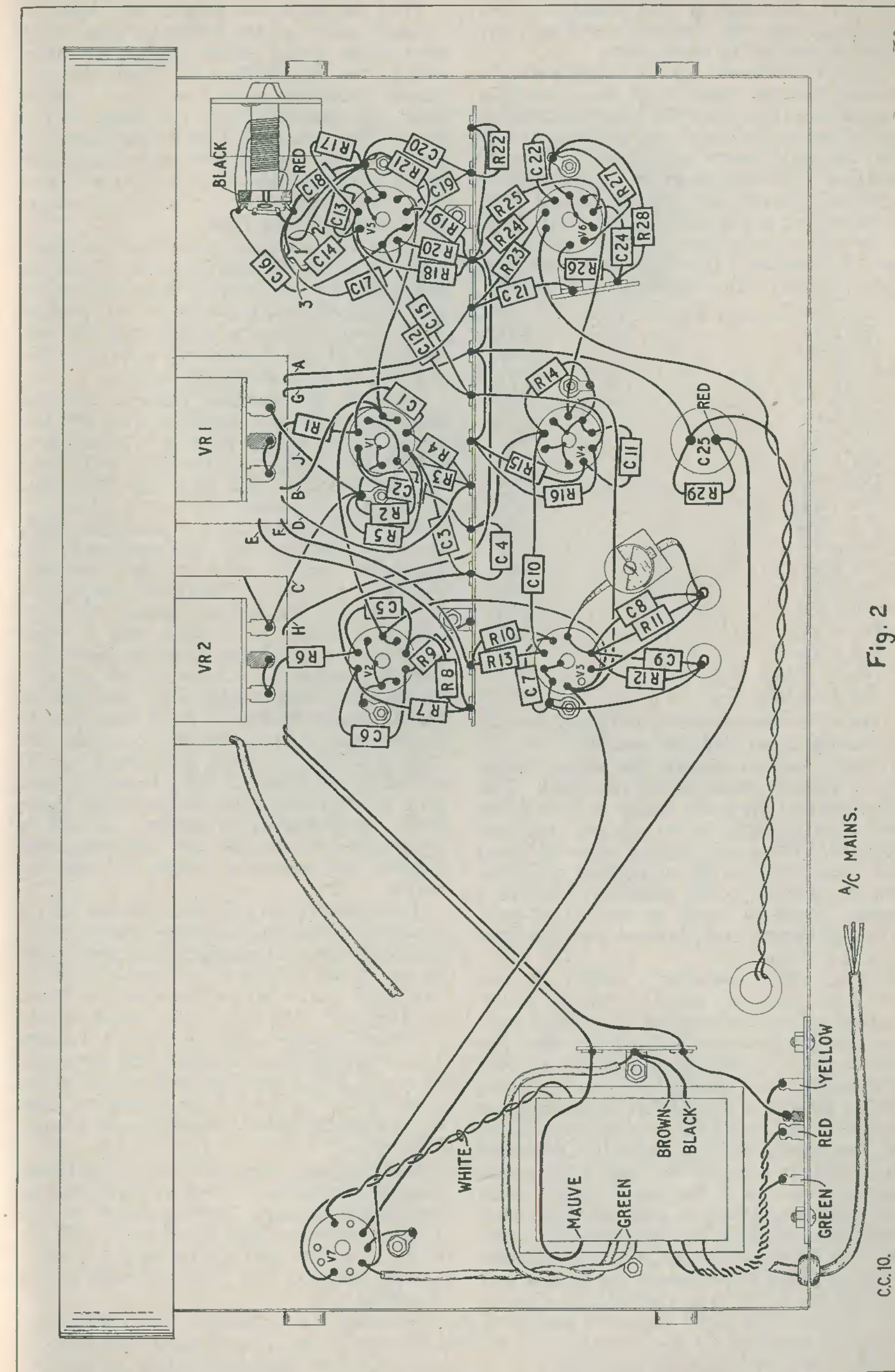



Fig. 2

spent in checking is well spent, as any mistakes may be rectified without any possible damage to components.

(*b*) An ohmmeter connected between the chassis and the junction of $R_{29}$ and $C_{25b}$ should read about 20k–50k$\Omega$. On switching on the following voltages should be obtained with the "Selector" switch set to the "+ 10 kc/s" position. The voltages in the table should be regarded as giving the order of voltage to be expected and not necessarily the exact value, as tolerances in component values will cause some differences. The readings in the table were obtained with a 10,000 ohm/V meter.

| | |
|---|---|
| Junction $R_2$; pins 3 and 8 $V_1$ .. | 4V |
| Pin 1 $V_1$ .. .. .. | 95V |
| Pin 6 $V_1$ .. .. .. | 120V |
| Pin 1 $V_2$ .. .. .. | 70V |
| Pin 6 $V_2$ .. .. .. | 120V |
| Pin 7 $V_3$ .. .. .. | 105V |
| Pin 8 $V_3$ .. .. .. | 90V |
| Pin 1 $V_3$ .. .. .. | 15V |
| Pin 7 $V_4$ .. .. .. | 105V |
| Pin 8 $V_4$ .. .. .. | 125V |
| Pin 1 $V_5$ .. .. .. | 13V |
| Pin 6 $V_5$ .. .. .. | 75V |
| Pin 8 $V_5$ .. .. .. | 40V |
| Pin 8 $V_6$ .. .. .. | $4\frac{1}{2}$V |
| Pin 1 $V_6$ .. .. .. | 130V |
| Pin 6 $V_6$ .. .. .. | 20V |
| Pin 3 $V_6$ .. .. .. | 15V |
| Junction $R_{29}$, $C_{25b}$ .. .. | 135V |
| Junction $R_{29}$, $C_{25a}$ .. .. | 200V |

With the volume control set fully clockwise, a hissing noise will be audible from the speaker; and on tapping the output valve, $V_6$, a ringing noise should be heard. This indicates that the audio section is functioning and it is possible to set up the oscillator sections. There are several ways of doing this, depending on the equipment available, but the method to be described requires a signal generator with a minimum band coverage of from some hundreds of kilocycles to a few megacycles.

Switch the "Selector" switch to the +1 Mc/s position, and the "set 10 Mc/s" control so that the trimmer $VC_1$ is half open and the pointer on the knob on the scale datum mark. Screw the core of $L_{33}$ out with a non-metallic trimming tool (e.g. a knitting needle filed to a screwdriver shape) until an audible note is heard from the speaker. Carry on unscrewing until the note has decreased in frequency, passed through a zero and started to go up in frequency again. Screw the core in to the zero position. The same beat note will now be obtained on turning the "set 10 Mc/s" control, and the zero beat position of the knob should correspond with the datum mark The oscillator is now set to 10 Mc/s. The signal generator mentioned earlier is required for the setting up of the 100 kc/s and 10 kc/s multivibrators.

Plug the generator output lead into the "Input" socket of the calibrator and switch to a range giving about 2 Mc/s frequency swing over the whole scale. With the calibrator "Selector" switch set to +1 Mc/s, tune the generator over the range of the scale. Beat notes will be heard when the generator is swung through frequencies which are a multiple of 1 Mc/s. At this point it is possible to check the scale accuracy of the generator being used.

Select two of these beats and note their position on the generator scale. Tune the generator slowly between these two points and listen if any weak beats are present. With most generators, a spurious beat will be heard at the "half-way" position. The position of these should be noted.

To give an example, suppose that the generator is set to a range covering 250 kc/s to 2.5 Mc/s; strong beats will be heard at 1 Mc/s and 2 Mc/s and probably weak beats will be heard at 500 kc/s, 1.5 Mc/s and 2.5 Mc/s.

Now set the generator to 1 Mc/s (according to the calibrator and not necessarily the generator scale!) and turn the "Selector" switch to +100 kc/s. Swing the generator to 2 Mc/s and count the number of beats including those at 1 Mc/s and 2 Mc/s (neglecting any of the spurious beats previously noted which in any case will be found to be very much weaker than the genuine ones). Anything from 8 to 12 beats will be heard, and it is necessary to adjust the "Set 100 kc/s" control until there are 11 including the 1 and 2 Mc/s beats. A faint plop will be heard as the multivibrator jumps from one frequency to another. It will be appreciated that due to the synchronisation applied, the frequency cannot be smoothly varied.

To adjust the 10 kc/s multivibrator set the generator to a range covering some hundreds of kilocycles (our imaginary generator would be set to the 25–250 kc/s range). With the calibrator set as before, beats will be heard at 100 and 200 kc/s. On switching the "Selector" switch to the "+10 kc/s" position, a faint whistle will be heard, the frequency of which will depend on the setting of the "Set 10 kc/s" control. The procedure given for setting the 100 kc/s multivibrator is again followed.

With the unit wired according to the layout diagram and with $TC_1$ set to about half its maximum capacity, the frequency of the 1 Mc/s oscillator will be within ±100 c/s. It is, however, possible to obtain a much closer tolerance by the method to be described.

Provided the calibrator has been built according to the layout diagram, no difficulty should be experienced in setting up the unit.



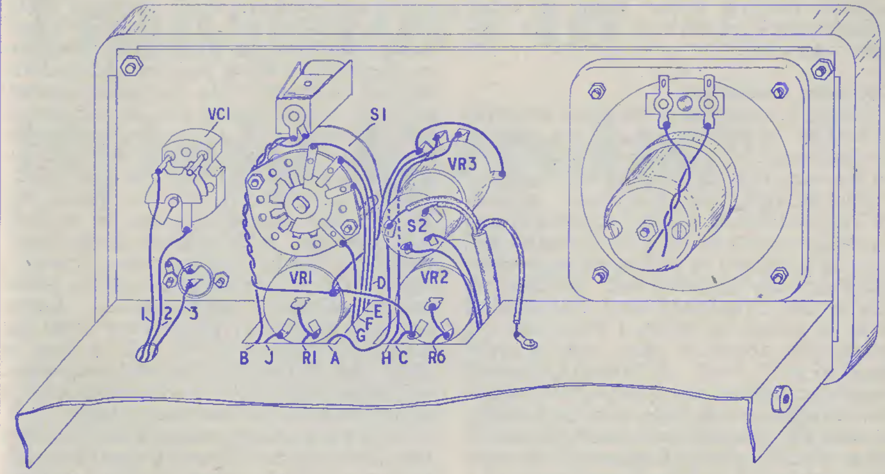



Fig. 3

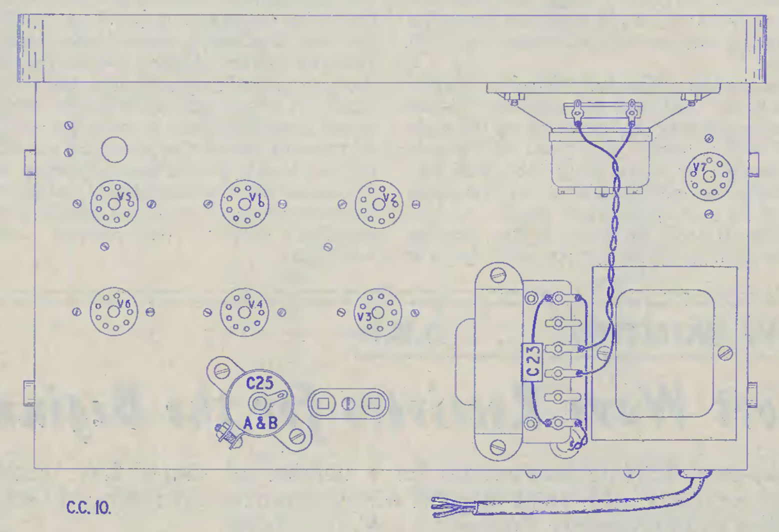



Fig. 4

The Jason Motor and Electronic Company will, however, undertake to test the calibrator if required.

It should be emphasised that the component parts should be obtained from a supplier retailing either Jason or other manufacturers' equivalents which are "designer approved."

**Operating Instructions**

On any range setting of the signal generator under test, the frequency at any one point of the scale must be approximately known with an accuracy which depends on the frequency.

For example, for frequencies between 10 kc/s and 900 kc/s, the frequency at one particular setting of the tuning control will have to be known to within 100 kc/s before calibration can be carried out. For frequencies between 1 Mc/s and 9 Mc/s, the frequency must be known to within 1 Mc/s, and for frequencies above 9 Mc/s, the accuracy required is 10 Mc/s. A little thought will show that these are not very stringent requirements, particularly as in the majority of cases the generator under test will already have a scale giving frequencies—however inaccurately. If not, the tuning scale of a domestic receiver into which the generator signal is fed can always be relied upon to give the frequency to the very wide limits laid down.

The actual calibration procedure is best explained by means of an example. Let us imagine that, at one range setting of the generator, the frequency range to be covered is reputedly 800 kc/s to 15 Mc/s; an unusually wide range, but one which serves as a good example.

If we set the calibrator "Selector" switch to "10 Mc/s" and turn the generator tuning knob over the scale at one point on the scale a "pip" will be heard. This point on the scale must clearly correspond to 10 Mc/s, and may tentatively be marked either on the scale itself or on a sheet of graph paper. At this stage the 10 Mc/s oscillator is free running and the calibration is not accurate, but the mark on the generator scale is certainly known to within 10 Mc/s. The calibrator can now be switched to "+1 Mc/s," at which point it will probably begin to howl due to the 10 Mc/s not being synchronised. This can be remedied by a small movement of the "set 10 Mc/s" control. The generator is then tuned again over the band and the positions on the scale at which pips are obtained are marked as before. The frequencies corresponding to these pips can be established with reference to the 10 Mc/s position which has already been established. The procedure is then repeated with the 100 kc/s multivibrator switched in; and, if required, the 10 kc/s multivibrator can also be brought into operation. If the position of the "pips" have been marked on graph paper, a smooth curve can now be drawn through the points and a calibration curve obtained. Before making a calibration the generator under test should be switched on for half an hour to allow the frequency to stabilise, otherwise confusion may exist if the various markings on the calibrator are not repeatable.

To achieve greater accuracy the following procedure may be followed to set the 1 Mc/s master oscillator closer to the nominal frequency.

It is well known that the carrier frequencies of B.B.C. transmitters are maintained to very close limits; in fact, the 200 kc/s Droitwich Long Wave Transmitter frequency is maintained within the outside limits of ±0.004 c/s.

If the output of a signal generator is fed into any receiver covering the long waveband, the signal generator may be set to 200 kc/s by zero beating it against the Light Programme carrier. If now the output lead of the generator is plugged into the calibrator input, $TC_1$ may be set for a zero beat. The signal generator must be switched on at least 15 minutes before this is carried out for it to attain a steady temperature, ensuring that the frequency will stay reasonably stable between the short period when the output lead is being switched between the receiver and the calibrator.







# Transistors in Hybrid Circuits

by F. L. ASH

ALTHOUGH NUMEROUS ARTICLES HAVE appeared, both in this magazine and others, on transistor circuits, very little has been written about using transistors in conjunction with valves in hybrid circuits. In the following paragraphs, some of the problems involved in using transistors and valves together are discussed.

One possible application of the transistor is as the voltage amplifying stage in a portable receiver. There are several possible arrangements in this application, and these will now be considered. Since the transistor output will be fed into a high impedance circuit (i.e. the grid of the output valve), either a grounded base or grounded emitter circuit can be used. The latter has a higher input impedance, which is preferable when feeding from the detector circuit, and this arrangement will be considered first.

The first problem is the transistor supply, which for p-n-p types must be negative with respect to earth. In hybrid circuits such as this it is always desirable to avoid the use of a separate battery for the transistor. The l.t. supply of 1.4V is too low if the transistor is to be used with a resistive load. Fortunately a convenient supply already exists—the back bias developed for the output valve. In the case of the DL96 output valve this is approximately 5.2V. The circuit arrangement is shown in Fig. 1.

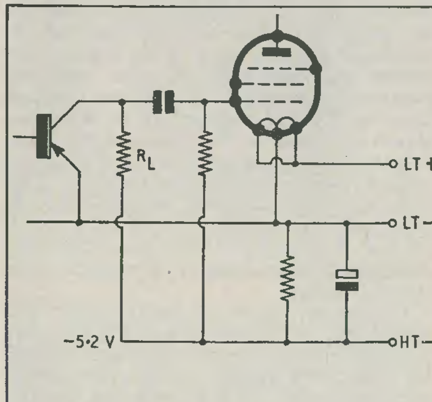



FIG. 1.

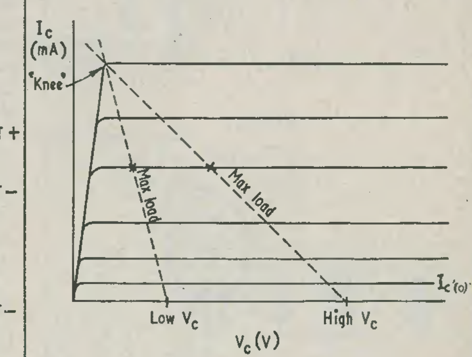



FIG. 2.

G562

The biasing arrangement for the transistor is not shown in this circuit. Should a higher transistor supply be required, an extra 1.4V can be obtained by returning the emitter to l.t.+ instead of l.t.−.

As in the case of valves used as voltage amplifiers, in general the higher the load the higher the voltage gain, although there is a maximum value for the load. Beyond this value, the gain stays constant, but distortion increases.

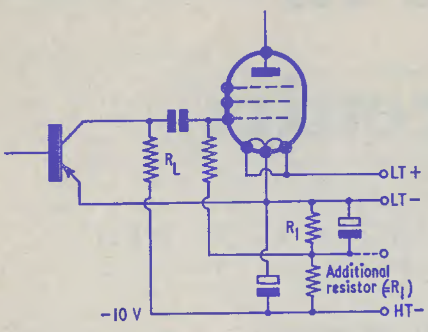


FIG. 3.

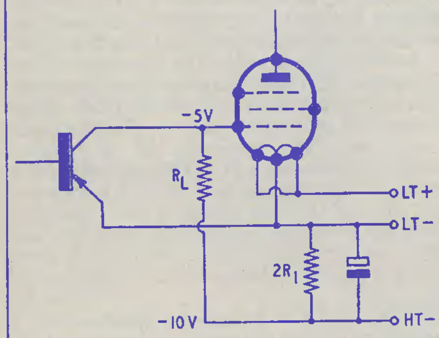


FIG. 4.

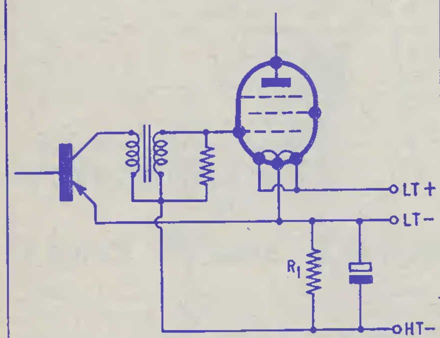


FIG. 5.

G563

The value of transistor load which can be used is limited by three main considerations. The first of these is the collector supply voltage. The higher the collector supply voltage the larger the load can be made, since for a given collector current more voltage can be dropped across the load, whilst still maintaining a workable voltage at the collector itself. The second factor is the "knee" of the characteristic. Operation below the knee (i.e. with high values of load resistance) will result in severe distortion. The third factor is collector leakage current ($I'_{c(o)}$) which is temperature sensitive. An increase in temperature will raise the leakage current and drive the operating point further up the load line towards the knee. These factors are illustrated in Fig. 2.

For these reasons a fairly low value of load must be used, 4.7kΩ being a typical value, with a maximum of about 12kΩ.

To return now to the circuit of Fig. 1. This will give quite good results but it is not possible to fully load the output valve. From the valve data for the DL96, it will be seen that an input voltage of 3.4 volts r.m.s. is required to fully load the valve. This corresponds to a peak input voltage of 4.8V (almost equal to the bias voltage). Thus the grid is driven from the normal bias point up to −0.4V, and back to −10V for full output, a peak-to-peak voltage of 9.6V.

Since a supply of only 5.2V (or 6.6V) is available, the peak-to-peak drive from the transistor cannot exceed this value, and the output valve will be underdriven. This will be found to hold true for any battery-operated output valve. The difficulty can be overcome by quite a simple modification. If an additional resistor, equal to the existing bias resistor, is connected in series with the negative h.t. terminal, an additional voltage equal to the bias voltage will be developed across this resistor. The bias voltage is taken from the same point as before, and this extra voltage used to supply the transistor. (See Fig. 3.) The additional resistor must be adequately decoupled.

Care must be taken that the voltage does not exceed the maximum value for the transistor, of course.

If suitable values of load resistor and operating current are chosen for the transistor, it can be arranged that the voltage at the collector is equal to the bias required for the output valve. If this is the case, the grid capacitor and resistor can be omitted and the two stages directly coupled, as shown in Fig. 4.

**Transformer Coupling** (Fig. 5)

If the maximum gain is required from the transistor, transformer coupling should be used. The maximum value of the grid resistor should be used for the output valve (3MΩ in the case of the DL96) and the transistor matched to this. The optimum load for a transistor is given by:-

$$R_L = \sqrt{r_{22}\, r_{out}}$$

where $r_{22}$ is the output impedance with the input open circuited, and $r_{out}$ is the output impedance with the input short-circuited.

For the OC71, the value is about 12kΩ. Thus the ratio of the transformer required is:

$$\frac{3{,}000{,}000}{12{,}000} = 16:1$$

With transformer coupling, it is not necessary to use a high collector supply voltage, and the bias voltage may be used direct.

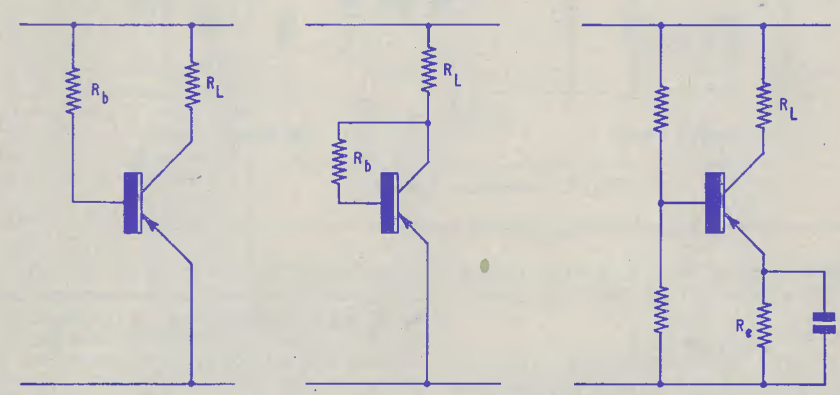


FIG. 6. Three methods of biasing transistor

G564

**Biasing and D.C. Stabilisation**

The simplest method of biasing the transistor is by means of a base resistor from the negative line. The required value is given by:

$R_b = \frac{V}{I_b}$ (where V is the supply voltage and $I_b$ the base current).

This method of biasing does not safeguard against the possibility of the operating point shifting with rise in temperature, and a simple method of providing some compensation is to take the bias resistor from the collector instead of the negative line. Some gain is lost by this method, as negative feedback is applied to the transistor. The voltage at the collector (instead of the supply voltage) must be used when calculating $R_b$ in this case.

A more successful, although more elaborate, method of stabilising the working point is to use potentiometer biasing, together with an emitter resistance. The value of emitter resistance used will depend on the degree of stabilisation required but it is usually about 1kΩ (20 to 25% of $R_L$). The voltage drop across the emitter resistor can be determined from the current flowing, and the base-to-emitter voltage required to give the correct base current can be found from the transistor input curves.

The current through the base potentiometer is made an order of magnitude larger than the base current, and the voltage at the base is made equal to the emitter voltage plus the required base-to-emitter voltage. All these three methods of biasing are shown in Fig. 6.

**Input Impedance**

The grounded emitter circuit has a low input impedance (compared with valve circuits), normally of the order of 1 to 2kΩ. If maximum gain is to be obtained, some matching will be required; this can be done either by using a step-down transformer after the detector, or arranging that the secondary of the i.f. transformer is tapped, and is suitable for feeding a low impedance diode detector circuit.

If no base bias current is provided for the transistor, it will function as a detector, but its operation is then dependent on $I'_{c(o)}$, and there is no straightforward method of applying d.c. stabilisation to this circuit. It is therefore preferable to use a separate diode preceding the transistor.

**Grounded Base Circuit**

Although transformer coupling is necessary when using grounded base transistors in cascade, a single stage used as a voltage amplifier with a resistive load will give a higher voltage gain than a grounded emitter stage. The input impedance is much lower (100Ω to 200Ω) and the output impedance higher than with a grounded emitter circuit. It is less temperature dependent, and does not require d.c. stabilisation. It can be used in any of the arrangements described. There are two possible methods of biasing the emitter. Providing the base is returned to l.t.−, the l.t.+ supply can be used as a

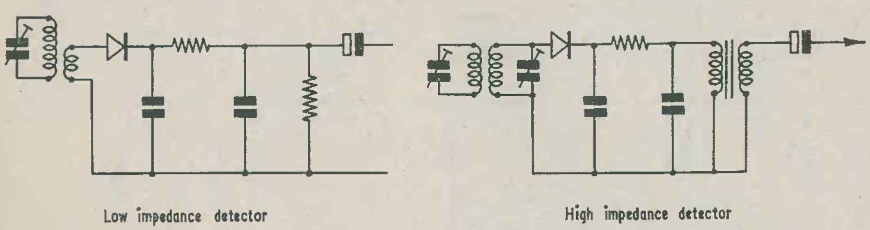


FIG.7. Alternative input circuits

G565

convenient source for the positive emitter bias. The value of the emitter resistor is given by $R=\frac{V}{I_e}$.

If $V=1.5V$, and $I_e=0.5mA$, $R=3k\Omega$.

The alternative method is to bias the base negatively as before, and return the emitter to earth via a resistor. The input is then applied to the emitter.

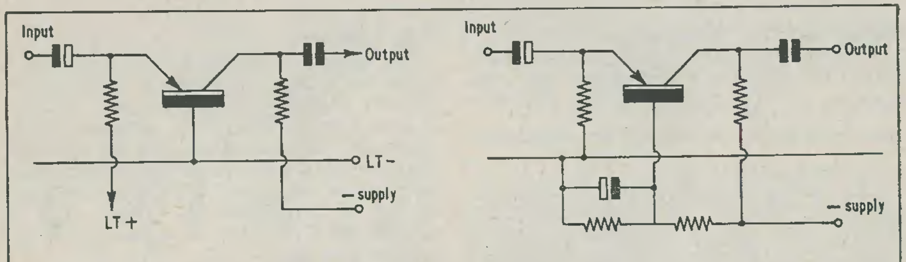


FIG.8. Methods of biasing grounded base stage

G566

Since the impedance looking into the transistor is much lower in this connection, it is important to match the high impedance of the detector circuit by means of a transformer. Assuming the diode circuit has an impedance of 500kΩ, a transformer ratio of at least 50:1 would be required.

**Microphone Pre-amplifier**

The low input and high output impedances of a grounded base stage are useful when it is required to feed from a low impedance—such as a moving coil microphone—to a high impedance—such as the grid circuit of a valve. Here again the transistor supply can usually be obtained from the amplifier itself, the cathode bias voltage of the first valve providing a suitable source.

Since this is a positive source the cathode end of the bias resistor must be considered as the "earth" point as far as the transistor is concerned, the true earth line being regarded as the negative supply line. A typical circuit is shown in Fig. 9. It should be noted that the cathode bias resistor must be decoupled. If this is not possible for any reason—negative feedback being applied to the cathode, for instance—the bias voltage of another valve in the amplifier may be used as a supply. As before, care must be taken to ensure that the maximum voltage for the collector is not exceeded. If the bias voltage is too high, the bias resistor can be replaced by two resistors in series, and the transistor supply taken from the junction of the two. The values of the resistor must be suitably chosen to give



the correct bias for the valve, and the correct voltage for the transistor, and the junction must be decoupled.

**Coupling Capacitors**

To readers familiar with valve circuits the values of coupling capacitors used with transistors may seem uncommonly high. This is due to the much lower input impedance of the transistor. The coupling capacitor and the input impedance together form a bass cut circuit. In the case of a valve with a grid resistor of 500kΩ, a capacitor of about 0.005 μF will be suitable for operation down to about 60 c/s.

To work satisfactorily down to the same frequency with a grounded emitter circuit which has an input impedance of only 1kΩ we should need a coupling capacitor of 2.5μF. With a grounded bass circuit the input impedance is even lower (about 100Ω) and a capacitor of 25μF would be required to obtain similar low frequency response.

Since small electrolytics are normally used for these purposes, the correct polarity must be observed. In general, the positive end is connected to the "earthy" side of the circuit.

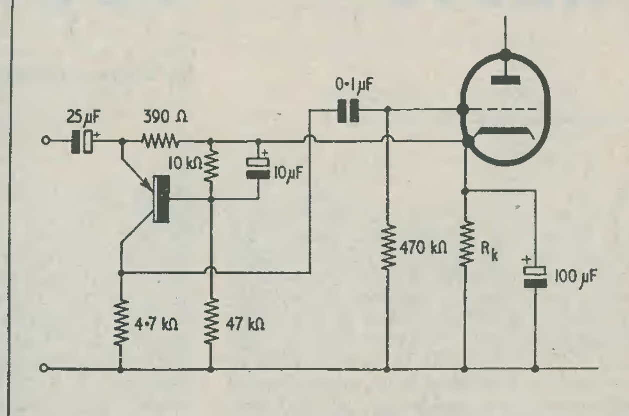


FIG.9. Microphone pre-amplifier

G567

## American Award for Member of English Electric Valve Co. Staff

Mr. F. Langford-Smith, B.SC., B.E. (1st Class Honours), Senior Member I.R.E. (U.S.A.), has been named an Honorary Member of the Audio Engineering Society of the U.S.A. by the Society's Board of Governors.

Under the bye-laws of the Society, honorary membership may be presented to persons of outstanding repute and eminence in the science of audio engineering or any of its allied arts. The 1959 Awards Committee of the Society announced that Mr. Langford-Smith has been elected in recognition of the importance of his book, entitled Radio Designer's Handbook (Radiotron Designer's Handbook in the U.S.A. and Australia), to the education of a generation of audio engineers.

Mr. Langford-Smith, who is head of the Technical Publications Department at the English Electric Valve Company, will be visiting America during the New York Convention of the Society in October to attend the annual Awards Banquet, where A.E.S. awards are usually made.

## 1960 ELECTRICAL ENGINEERS' EXHIBITION

Yet again, a bigger-than-ever Electrical Engineers Exhibition at Earls Court is forecast for next spring (5th to 9th April).

Formal confirmations of earlier provisional space bookings indicate that around 450 manufacturers will show their products.

The large number of new exhibitors has made it necessary to increase the number of first floor stand sites and the forthcoming show will have nearly five miles of stand frontages.

The ballot for stand positions was held at Caxton Hall, London, on Wednesday, 14th October.

The "Marine Electrics" feature will occupy 5,000 square feet on the first floor. This will prove to be an extremely topical feature as the exhibition period will be near to the launching date of the largest passenger vessel to be built in the United Kingdom since the Queens. This ship, the P. & O. *Canberra*, will be the largest British passenger ship to be powered entirely by a.c. and will include much specially designed electrical equipment.

It will be propelled by 85,000 s.h.p. twin-screw turbo-electric machinery, having four turbo alternators giving an output of six megowatts.

In addition to new developments displayed within the exhibition feature, many of the exhibitors will include marine electrical equipment on their stands.

# RADIO — Topics

By Commentator

### Kits

HAVING JUST COMPLETED CONSTRUCTING his second Heathkit and being about to start the third, your commentator somewhat naturally fell to reflecting what an advance the Heathkit method of assembly was over that of the days when he first began building radio gear. "Chassis bashing" was —and still is—the most tedious of occupations; and the drilling of holes, sorting out of components, and soldering in awkward places, all took a toll of the pleasure the final article eventually gave. Many attempts have been made in the past to relieve the home constructor of these monotonous tasks, but few have stood the test of time. We recall, for instance, attempts some years ago to introduce a series of chassis parts in which strips with valveholder holes were bolted to flats, ends and sides to make up the required chassis assembly. But this did not last long. Far more popular were the metalwork firms who would make up chassis to one's specific requirements. One firm, at least, has built up a permanent, successful business from this line. For the constructor who wants "one-off" a job to his own requirements, this is the answer. But for the builder of popular lines of equipment, the Heathkit system would be very difficult to improve upon. Everything from cut and drilled chassis, to all bolts, washers and nuts, components, connecting wires, solder and insulating tape—all is provided, and the constructor can go straight ahead, step by step, knowing that everything will work out correctly, that all the snags have been ironed out, and the design is such that very satisfactory performance is guaranteed when the job is completed.

### Amateur Bands

The International Telecommunications Union Conference at Geneva will, no doubt, produce some changes in the amateur transmitting band allocations. Most of the major amateur radio organisations are taking steps to see that their facilities are well represented in the right quarters. Some of the most drastic suggestions for cutting these which we have read to date have come from the Australian Government. We were interested to note that the defence against these suggestions put up on behalf of the Australian amateur organisations made great play of the part Amateur Radio has taken in providing emergency radio communications in natural disasters. It is only recently that British amateur radio has organised its own "community service" of this nature. We hazard a guess, however, that this aspect of amateur radio will carry more weight than any other in the eyes of the "powers-that-be," when the final decisions regarding the future of amateur radio allocations are drafted.

### National Radio Show

Another National Radio Show has come and gone. Your commentator is one of those who finds the exhibits on the first floor of considerably more interest than those on the ground floor. The guided missiles and their associated equipment, and the delightful model of one of the new County Class guided missile naval vessels, provided exhibits of great interest. One hopes for still more of this type of display in future shows.

### Noise

The Noise Abatement Society is unfortunately a most necessary addition to the organisations endeavouring to make our civilisation tolerable for human beings to live in. This summer's weather has made the nuisance of the over-loud outdoor portable radio a matter which this new Society might well pay some attention to—after it has dealt with motor-bikes as a priority job. Like so many evils of civilisation, noise is primarily a matter of thoughtlessness on the part of its creator. Publicity about the evils of noise and communal education against it should help very materially in bringing about a great reduction in its general level.



### *QSL's*

It was surprising to read in a recent RSGB *Bulletin* that over a million QSL cards are handled by the Society QSL Bureau each year. An old-timer like your commentator has long ceased to get much of a thrill from the packet of QSL's on the doormat, but his memory is sufficiently good to vividly recall the days when he did handle QSL's with a reverence more fitting to some token of religious significance. Still, even now, those cards which strike a new style or have a photo of their originator or his QTH or gear on them do give pleasure and add interest to his hobby. It is a pity more folk do not use QSL cards with photographs on. The Americans, perhaps, give a lead to this with many of their cards, as the practice seems more widely spread there than elsewhere. In so doing, the recipient of the card is better able to get to know the chap he has been in contact with than is the case when he gets nothing more than a plain printed card. The Iron Curtain countries have been quick to realise the value of the pictorial QSL card. Almost without exception, their QSL cards show some features of their QTH's. So the next time you get some new cards done, see if you cannot run to a pictorial one.

### World Radio

From a review of a UNESCO publication —*Broadcasting Without Barriers*—one learns that more than 9,000 radio broadcasting transmitters and 335 million receivers bring information and entertainment to the world's peoples. However, the distribution of all this "mass communication" is apparently very uneven. Nearly sixty per cent of the world's population are without adequate radio broadcast services. Sixty per cent of the world's radio transmitters and eighty per cent of its receivers are concentrated in North America and Europe. Asia and Africa are the most under-developed continents in this respect. It is estimated that an additional 350 million receivers would be needed to assure a set for each family. So it looks as though there should be a good market for "steam" radio for many a long day yet!

We regret that, owing to continued ill-health, Centre Tap has had to give up, temporarily, the writing of his popular feature "Radio Miscellany." Centre Tap has been a regular contributor to our columns from our first issue, and we are sure readers will join with us in wishing him a speedy recovery to full health.

### Your Show

By the time this is being read, the RSGB International Radio Hobbies Exhibition will be in the offing. It is to be held at the Royal Horticultural Society's Old Hall, Vincent Square, London, S.W.1, from 25th–28th November. This is the radio constructors' show, and a visit to it by all who can get to it is very well worth while. So we'll hope to see you there, on Stand 24.

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# A New Series of Mullard Filmstrips

## For the student electronics engineer

The Mullard Educational Service has announced the introduction of a new series of filmstrips designed to assist the teaching of electronic engineering in technical colleges, services training establishments, industrial apprenticeship courses, and so on.

The first of the series—"Thermionic Oscillators"—is available now from the distributors, Unicorn Head Visual Aids Ltd., 42 Westminster Palace Gardens, London, S.W.1, price 25s. a copy, including comprehensive teaching notes. The second, which deals with non-sinusoidal oscillators, is in preparation, and will be followed by others covering the subjects of modulation and transmission.

"Thermionic Oscillators" comprises 27 colour frames, arranged in two parts, with the break occurring at a convenient point in the development of the subject.

Part One starts with an explanation of the basic principles of electronic oscillation, using the mechanical analogy of the loaded spring. Some revision of a.c. theory and resonance is then given, and finally the operation of various forms of simple electronic oscillators—the Meissner, Hartley and Colpitts circuits—is examined in detail.

The subject is resumed in Part Two with explanations of Miller-effect, electron-coupled and crystal-controlled oscillators, and the strip concludes with an examination of a typical practical circuit comprising oscillator, buffer amplifier and output amplifier.

# Getting Started on RTTY

**by Arthur C. Gee, G2UK**

*Hon. Sec., British Amateur Radio Teletype Group*

REGULAR READERS OF THIS PERIODICAL will know that in February, March and April last there was published a series of three articles on amateur radio teletype from the well-known exponent of this subject, James T. Hepburn, VE7KX, of Richmond, B.C.

These articles produced sufficient interest to warrant the inauguration of a Group specifically devoted to furthering the cause of RTTY in the British Isles. Within a matter of weeks the Group had a membership of fifty, had acquired a number of teleprinters, built receiving FSK converters and at the time of writing is just about ready to start the first "G" RTTY QSO's.

Some twenty-five or so teleprinters have been issued to BARTG members and it is hoped that further supplies will become available, but the author was surprised to learn from correspondence with members in the early days of the Group that quite a number of people had already acquired printers from one source or another. Some had even been "RTTY listeners" for a number of years. Quite obviously, there was a nucleus of interest in this subject which needed drawing together. Also, technical data was badly wanted. Various scraps of information had been gleaned by various members as a result of personal experience, service training and so on, but no detailed account of "amateur radio RTTY" was available. So a series of News Sheets was issued giving the essential data. These of necessity had to be brief. Thanks to the kindness of our editor, who has made space in this journal available, we hope in this series of articles to enlarge on this subject and make the information the Group has acquired available to a wider readership.

First of all, just what is "RTTY"? Telegraphic equipment which would "write" down the message being sent can be traced right back to the beginnings of electrical telegraphy. Samuel Morse's original invention used a pen, moved by the electrical impulses, to record his code on a moving paper tape. Many subsequent efforts were made to develop an electrical instrument which would record the messages in letter form, but they were unsuccessful until a Frenchman named Baudot realised that the main difficulty was that codes such as Morse's gave such differing lengths of signal for the various letters. "J" for instance is thirteen times as long as "E" when sent by morse code. Baudot introduced a code in which all the characters are of the same length, but are made up of differing groupings of impulses. It then became possible to develop electromechanical means for recording the messages in actual printed form.

The signalling code used in teleprinters met with in this part of the world—known as "International Telegraph Alphabet No. 2"—consists of a group of five impulses. Each set of five impulses occupies the same time interval; the various letters, figures and other intelligence being conveyed by various permutations of these five impulses.

Each five-impulse signal permutation is preceded by a "start" impulse, which releases the receiving printer mechanism. After each five-impulse sequence, a further "stop" impulse is sent which stops the printing mechanism.

This type of teleprinter operation is known as the "start-stop" system, i.e. the receiving mechanism is at rest until a signal is received. After the signal has actuated the receiving printing mechanism, the latter stops until another signal is received. There are other types of teleprinter systems in which the receiving mechanism rotates continuously, printing on the reception of impulses from a transmitting mechanism rotating in step with it. These systems are called synchronous systems. The advantage of the "start-stop" system is that the receiving mechanism and the transmitting mechanism do not get out of step with each other, as is liable to happen in the synchronous systems. The latter need very accurate speed control and suffer from the disadvantage that any slight inaccuracy in this respect is cumulative.

| | Optional characters | Start ○ | Code Elements 1 | 2 | 3 | 4 | 5 | Stop ● |
|---|---|---|---|---|---|---|---|---|
| A | | | ● | ● | ○ | ○ | ○ | |
| B | ? | | ● | ○ | ○ | ● | ● | |
| C | : | | ○ | ● | ● | ● | ○ | |
| D | who are you | | ● | ○ | ○ | ● | ○ | |
| E | 3 | | ● | ○ | ○ | ○ | ○ | |
| F | | | ● | ○ | ● | ● | ○ | |
| G | | | ○ | ● | ○ | ● | ● | |
| H | | | ○ | ○ | ● | ○ | ● | |
| I | 8 | | ○ | ● | ● | ○ | ○ | |
| J | Bell | | ● | ● | ○ | ● | ○ | |
| K | ( | | ● | ● | ● | ● | ○ | |
| L | ) | | ○ | ● | ○ | ○ | ● | |
| M | . | | ○ | ○ | ● | ● | ● | |
| N | , | | ○ | ○ | ● | ● | ○ | |
| O | 9 | | ○ | ○ | ○ | ● | ● | |
| P | 0 | | ○ | ● | ● | ○ | ● | |
| Q | 1 | | ● | ● | ● | ○ | ● | |
| R | 4 | | ○ | ● | ○ | ● | ○ | |
| S | ' | | ● | ○ | ● | ○ | ○ | |
| T | 5 | | ○ | ○ | ○ | ○ | ● | |
| U | 7 | | ● | ● | ● | ○ | ○ | |
| V | = | | ○ | ● | ● | ● | ● | |
| W | 2 | | ● | ● | ○ | ○ | ● | |
| X | / | | ● | ○ | ● | ● | ● | |
| Y | 6 | | ● | ○ | ● | ○ | ● | |
| Z | + | | ● | ○ | ○ | ○ | ● | |
| Carriage return | | | ○ | ○ | ○ | ● | ○ | |
| Figures | | | ● | ● | ○ | ● | ● | |
| Letters | | | ● | ● | ● | ● | ● | |
| Line feed | | | ○ | ● | ○ | ○ | ○ | |
| Space | | | ○ | ○ | ● | ○ | ○ | |

Fig.1

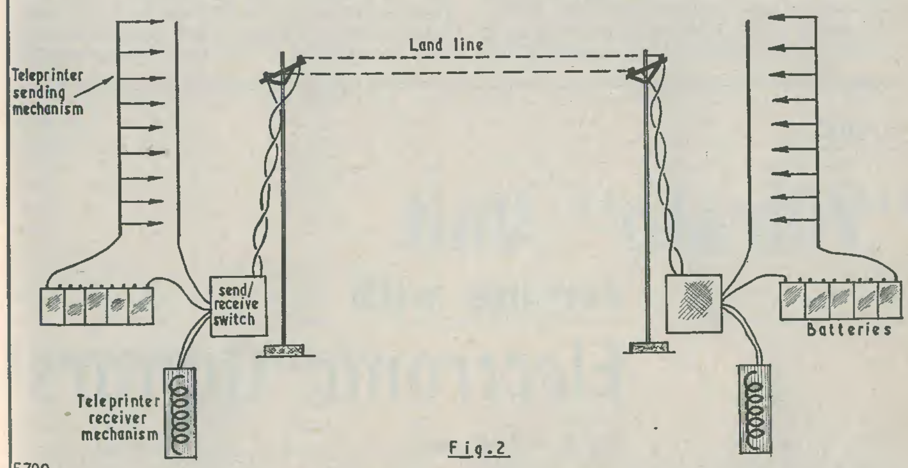



Fig.2

The teleprinter impulse code is shown in Fig. 1. Each impulse lasts for a definite, but very short space of time. For instance, the start impulse lasts for only 20.41 milliseconds. The stop impulse lasts for 30.61 m/secs. The code impulses are also of 20.41 m/secs. duration. These times are those used in the English standard, which is used over much of Europe and a very large number of world-wide circuits. The American system uses different timing for the impulses, viz., 22 m/sec. for start and code elements and 31 m/sec. for the stop impulse. We shall discuss this difference later on in this series of articles.

So much for general principles. How are

the machines connected up in practice? In the simplest circuit, the machines can be connected as shown in Fig. 2. Here we have the transmitting mechanism which is worked by the teleprinter keyboard contacts, in series with the receiving mechanism of a second teleprinter at a distant point. Normal telegraph land lines convey the impulses from one to the other. Now we could easily use a radio circuit in place of the land lines and this is, of course, what is done in a radio teletype circuit. The system would work if we used a simple make and break radio circuit, similar to c.w. morse code transmission, but using the teleprinter code instead of morse code. This was actually done in the early days of amateur radio teletype, but a number of snags very soon showed up in this mode of operation. It was soon superseded by the "FSK" or frequency shift keying system of radio communication. With this system, a continuous carrier is radiated by the transmitter but it is shifted in frequency slightly by the impulses from the teleprinter transmitting mechanism. Thus the radio signal varies in frequency in keeping with the impulses of each code sequence. At the receiving end, the received radio signal is made to beat with the beat frequency oscillator on the receiver, in the same way as is done for a c.w. signal, but instead of a make-and-break audio tone being produced, a two-tone audio signal is produced, the two tones being the amount of the frequency shift used at the transmitter. The two tones reproduce the impulses sent by the teleprinter. These two tones are fed into a tuned audio circuit which discriminates each tone and feeds it into an electromagnet which in turn keys the receiving mechanism on the receiving teleprinter. The amount of shift used in amateur transmissions—and in many commercial ones as well—is 850 cycles per second. At the receiving end the two tones produced are adjusted so that one is of 2975 c/s and the other 2,125 c/s.

It would, of course, be possible to send the two audio tones over a radio carrier as an ordinary modulated signal, as one does with normal phone transmission. This system is used and is known as AFSK—audio frequency shift keying. It is not so reliable as f.s.k., being more susceptible to fading, atmospherics, and so on, but it is used on v.h.f. circuits, particularly in amateur practice. It can be used with a.m., n.b.f.m. or f.m., and will be dealt with later on in this series of articles. For the moment we will confine out attention to f.s.k., as this is the mode used on the normal short wave circuits.

It will be apparent, by now, that two additional units are needed to enable the normal amateur transmitting station to be used for RTTY. First of all a unit is required which will shift the frequency of the transmitter 850 c/s. Then we need a unit for attachment to the receiver to convert the two tones produced by the shift back again into electrical impulses sufficiently powerful to operate the receiving mechanism on the teleprinter. The first unit is applied to the oscillator section of the transmitter. We shall describe units for doing this in the course of these articles. The construction of the receiver converter will be dealt with in a near future article. Next month we shall deal with the heart of RTTY, the teleprinter itself.

AUDIO

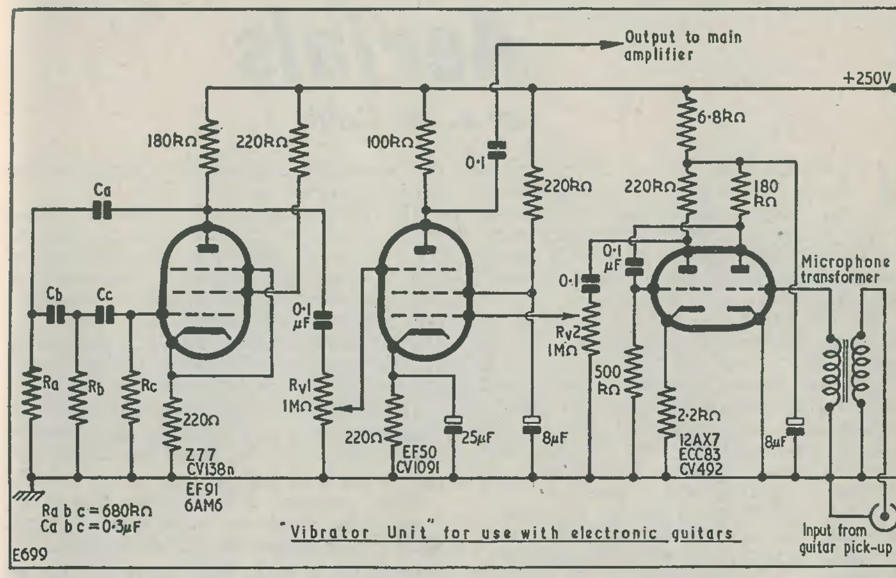
# "Vibrato" Unit for use with Electronic Guitars

By E. W. Bones

Originally designed to be added to an electronic guitar amplifier, this unit has proved very simple to adjust and operate, and has fully justified the small amount of time and money needed to build the instrument.

Basically the unit consists of a vibrato oscillator and a mixer valve, and a pre-amplifier.

The output from the pick-up is amplified by the 12AX7 stage and then fed to the control grid of the EF50 via $RV_2$, the pre-set volume control. To the suppressor grid of the same valve is fed the output from the EF91 "vibrato" oscillator (via the pre-set control $RV_1$). These two signals are mixed and as a result the signal from the pick-up is modulated in amplitude at a frequency of about 3 c/s, giving the well-known "vibrato" effect.



"Vibrator Unit" for use with electronic guitars

The output from the EF50 is then fed to the main amplifier in the usual manner, but the level is such that a high gain input is not needed.

The circuit is quite usual and no comment is needed except perhaps regarding the oscillator, which is a quite conventional phase-shift oscillator. The main components are $C_a$ $C_b$ $C_c$ and $R_a$ $R_b$ $R_c$, and these components decide the frequency of the oscillator. It will be noted that the three resistors are the same value, also the three capacitors.

When setting up, the oscillator should be tested first. With the input from the mixer to the main amplifier there should be heard the low frequency note of the oscillator. This will be heard as a low "thumping" sound in the speaker.

If the guitar strings are plucked then the note will be heard, suitably modulated by the oscillator.

By adjusting the two controls $RV_1$ and $RV_2$ it will be found that there is an optimum position for best results, but always start with the controls at maximum to ensure that the system is working correctly.

After setting up the unit it will be found that it will be desirable to be able to switch the oscillator on and off. This is best done by inserting a normal jack in series with the cathode resistor (220) and feeding this to a foot-operated switch, so that when the switch is not operated, it is open circuit; a normal bell-push might be suitable.

In the actual construction there is nothing special to observe that one would not normally note in audio practice.

## Literature Received

We have received from Daystrom Ltd., manufacturers of the excellent and well known Heathkits in this country, a copy of their two-colour, 12-page brochure. This publication, which is free on request, fully lists the current range of home constructor kits available to the public at the present time The address is Daystrom Ltd., Gloucester, Glos.

From the Principal of the Weston-super-Mare Technical College we have received a 20-page booklet giving full and complete details of both full- and part-time courses for the session 1959-60. Among the long list of courses we note the following: Electrical Installations, Radio and Telecommunications, Radio Servicing, Television Servicing and the Radio Amateur's City and Guilds Course.

# V.H.F. Aerials

By A. W. Collis

The fundamental principles of aerial design are the same for all frequencies; but certain aspects of v.h.f. work require changes in these designs when working above 50 Mc/s. The importance of a good aerial cannot be over-emphasised in v.h.f. technique.

The simplest form of v.h.f. aerial is the familiar adornment of roof tops and chimney stacks, the centre-fed half-wave dipole (Fig. 1 (*a*)). From the diagram it can be seen that at the ends of the rods the induced voltage is a maximum and the induced current a minimum. In theory it would seem that the centre impedance (resistivity to an alternating current and voltage) is zero, whilst the ends represent infinity. In practice, however, the centre impedance is around 75 ohms, increasing to several thousands at its ends.

As the centre represents the lowest impedance load it is common practice to connect the transmission line there, as shown, the transmission line having the same impedance as the point of connection.

By splitting the common form of half-wave dipole into two or more parallel elements (in the same plane) with the connecting line attached to the centre of one of them, it is possible to match various line impedances. The pick-up of this dipole is equivalent to that of an ordinary single dipole, but as the current is now spread over several elements, each element will take only part of the current previously carried, which results in increased input impedance. This increase in impedance depends not only on the number of conductors in the folded dipole but also their diameters, as the latter affects the current distribution and therefore the input impedance. The most common form of folded dipole is the 2-element variety with conductors of the same diameter. When used just as a simple dipole and not part of a directive array its input impedance is near enough 300 ohms to make a good match to a 300 ohm twin lead.

The length and diameter of the dipole elements are also very important as it is the ratio of length/diameter that determines the bandwidth of the aerial.

The polar diagram of a vertical dipole, Fig. 1 (*b*), shows that the signal response is the same in all directions. To increase the gain of such a dipole aerial it is necessary to add "parasitic elements" known as reflectors and directors. Although these have no electrical connection to the dipole they serve to step up the effectiveness of the aerial system over that of the dipole alone.

The step up in power or gain is measured in decibels (dB) e.g. if $P_b$ and $P_a$ are the power inputs before and after aerial conversion, the gain in dB is $10 \log_{10} P_a/P_b$.

These parasitic elements when placed in front of the dipole are called directors, and when placed behind are called reflectors.

From the graph in Fig. 2 (*a*) it can be seen that on adding a director and reflector the greatest gain takes place when they are spaced at about 0.125λ and 0.15λ respectively.

The simplest form of directional aerial is the well known "H" type whose polar diagram is shown in Fig. 2 (*b*). This system gives a useful gain over the dipole and also gives the aerial a "blind spot," thus minimising interference from that direction. The length of the reflector should be just long enough to ensure that the reflected signal is in phase with that of the dipole, so as to add to the signal and not to oppose it.

The length for a reflector in feet is approx. $498/f$ (Mc/s) and that of the director approx. $450/f$ (Mc/s).

On adding these parasitic elements, it can be seen from the graph Fig. 3 (*a*) that the impedance of the system will alter. It is then necessary to match the new impedance of the aerial to that of the line, to ensure maximum transference of signal voltage. This may be done by using a transformer, as the square of the turns ratio is the impedance ratio. Also, the line will have to be matched to the input impedance of the receiver. Two simple ways of doing this are Fig. 3 (*b*) and (*c*); Fig. 3 (*b*) being the coil coupling method and Fig. 3 (*c*) the tapped coil method.



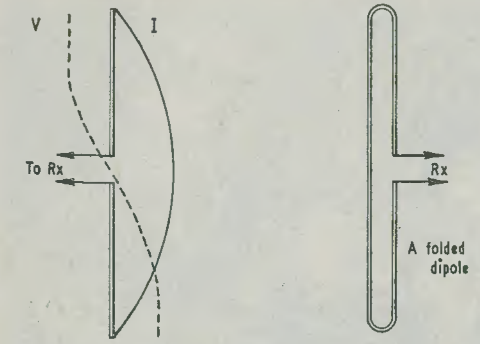



FIG. 1 (a)

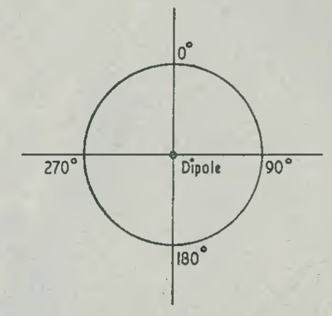



FIG. 1 (b)

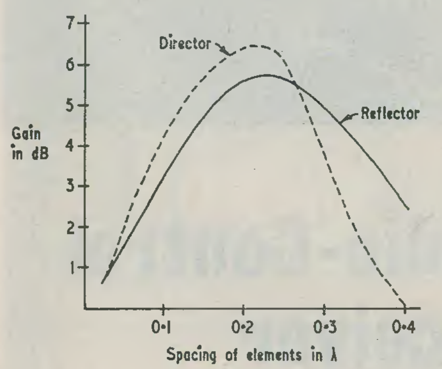



FIG. 2 (a)

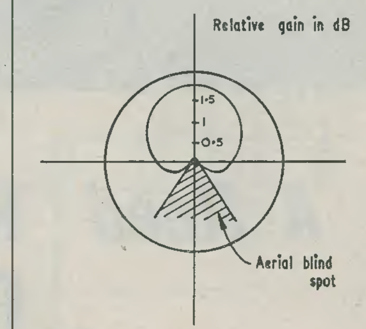



FIG. 2 (b)

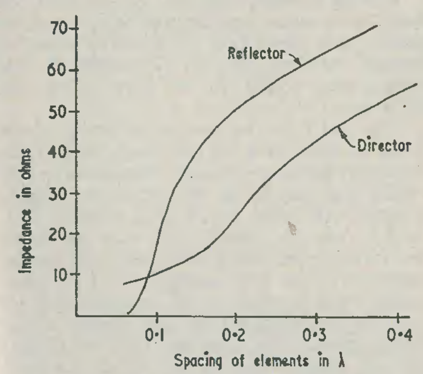



FIG. 3 (a)

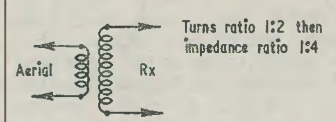



FIG. 3 (b)

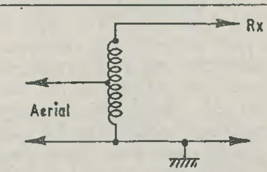
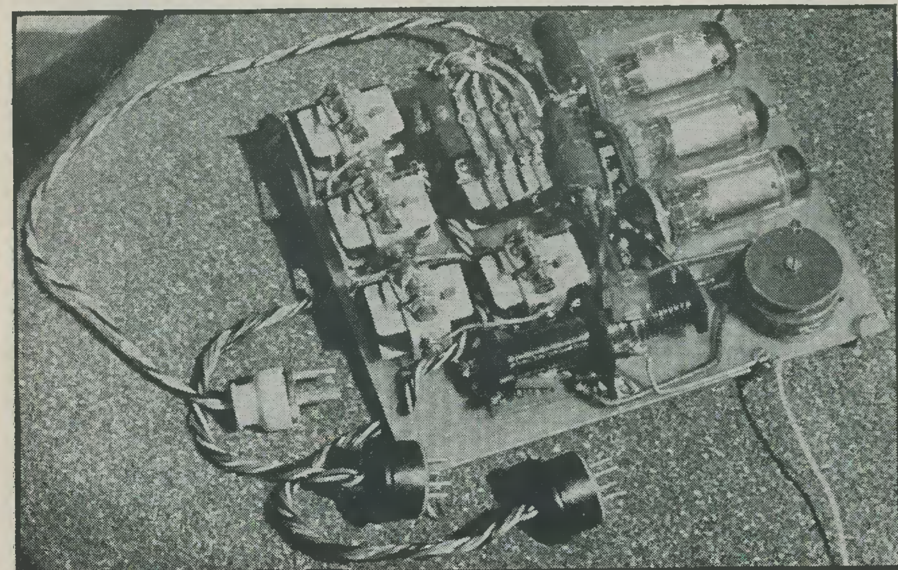



FIG. 3 (c)

G 575



# *A Reed* Radio-Control Receiver

By Michael A. Cole

**Description**

After having spent some time constructing Mark/Space Ratio gear, which tended to be rather bulky and considerably intricate, the receiver described in this article was built to combat the size and weight of the other system.

The receiver was constructed around three 3S4 type valves and a standard E.D. 3-reed unit. A home-built carrier wave transmitter was converted to give audio modulated output to work the receiver.

It was desirable that the receiver should be reasonably small and easy to get at, because of the number of adjustable components. With the intention of installing the receiver in a boat, a fourth reed was added to give: Starboard Rudder, Port Rudder, moving 10-position selector, and bringing selected control into operation.

Having thought this over, the receiver was based on a super regenerative detector circuit which was described in *Radio Control of Model Aircraft*, by G. Sommerhoff, and which was found to be very stable and reliable.

The coil $L_2$ is the tuning coil and is placed back to back with the sensitivity coil $L_1$, the windings being in opposite directions to each other and placed on $\frac{3}{8}$in diameter Aladdin formers cut down to $\frac{7}{8}$in long. The coils $L_3$ and $L_4$ are the quench coils and are wound on formers $\frac{1}{2}$in inside diameter, $1\frac{1}{8}$in outside diameter, and $\frac{1}{4}$in between the two inside faces, with a total of $\frac{1}{8}$in between the two sets of windings which are wound in the same sense. The relay position is taken up by the resistor $R_1$, across which the audio is taken off. The three valveholders are mounted on aluminium brackets, all in a line

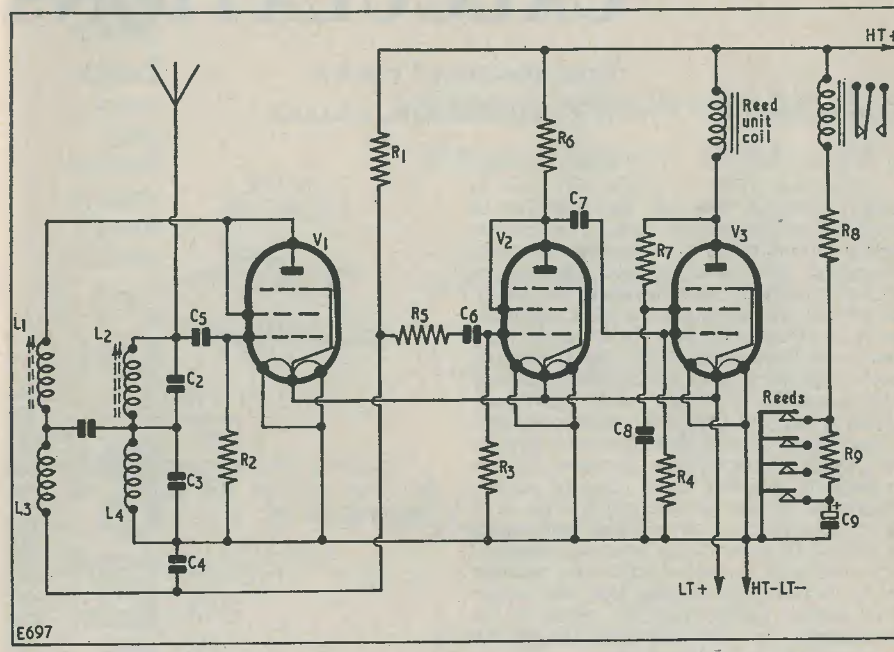


and the contact wires from the relays are taken to two B7G valveholder plugs so that the set is easily removable from the model.

The audio signal is then passed through a two-valve resistance-capacity coupled audio amplifier to the reed unit, which is placed in the anode of the last valve. Audio variations set up in the coil vibrate the particular chosen reed, which makes an interrupted contact to the relay. The interruptions are smoothed out by $R_9$, $C_9$ and finally by $R_8$ so that the relay pulls in when the chosen reed is set in motion. If less sensitive relays are used, not so much smoothing is needed. The circuit can be used for any of the reed units on the market at the time of writing.

In operation, on receiving the unmodulated carrier wave signal the 0–6mA meter in the h.t. line should drop from about 3.5mA to 1mA approximately, but rise to about 4.5–5mA on applying the audio signal.

If on a range check the receiver appears to be getting out of range, i.e. the current drop getting less when applying a c.w. signal, the sensitivity coil $L_1$ should be adjusted for greater current drop.




## COMPONENTS LIST

*Capacitors*

| | |
|---|---|
| $C_1$ | 500pF |
| $C_2$, $C_5$ | 100pF |
| $C_3$ | 1,000pF |
| $C_4$ | 5,000pF |
| $C_6$, $C_7$, $C_8$ | 0.01μF |
| $C_9$ | 3μF Picopack elect |

*Resistors*

| | |
|---|---|
| $R_1$ | 4.7kΩ |
| $R_2$, $R_3$, $R_4$, $R_7$ | 1MΩ |
| $R_5$, $R_6$ | 470kΩ |
| $R_8$ | 5.6kΩ |
| $R_9$ | 100Ω |

*Note*.—Repeat $R_8$, $R_9$, $C_9$ and relay for each reed.

*Coils*

| | | | |
|---|---|---|---|
| $L_1$ | 12 turns 24 s.w.g. | $L_3$ | 350 turns 38 s.w.g. |
| $L_2$ | 5 turns 24 s.w.g. | $L_4$ | 650 turns 38 s.w.g. |

MISCELLANEOUS

# TUNING COIL CALCULATIONS

*Some one-armed combat*

Conclusion

W. E. THOMPSON, A.M.I.P.R.E.

Multi-layer coils are dealt with just as easily, although they are less likely to be needed than single-layer coils. The formula which follows refers to a winding with turns touching. The usual method adopted by manufacturers is wave-winding for multi-layer coils, which reduces the self-capacitance to some extent and raises the Q value. Very few home constructors will be able to produce such coils, so it is to be expected that any coil produced at home with pile-wound layers is likely to have a fair amount of self-capacitance. It will therefore tend to tune to a lower frequency than calculated, but the remedy of removing some turns to achieve resonance at the required frequency is a fairly obvious step. Nevertheless the formula is sufficiently accurate for practical purposes, but obviously it cannot take into account slight variations in winding that may occur. The referee having said his piece to the contestants, we will commence the second bout and tackle the bigger chap.

**Big Brother, or 1984 $\mu$H and Beyond**

As we shall see, things have not altered a great deal. We use the same technique, but a little more of it. Referring again to the original formula

$$L=\frac{0.2N^2D^2}{3.5D+8S}\times\left(\frac{D-2.25d}{D}\right)$$

it will be remembered that the term in brackets is the correcting factor for a multi-layer coil. Looking at what lies ahead, it will save some mental gymnastics if we represent this term by the symbol "k"; it will permit easier working in rearranging the formula, and we can revert to the full term when it is convenient for us to do so.

Assume that battle has commenced, and that we have by now reached the stage of initial struggling in Hold No. 2. Going through the motions once more, we apply

**Hold No. 3—Hari-kiri**

$$L=\frac{0.2N^2D^2k}{3.5D+8S}$$

$$=\frac{N^2D^2k}{17.5D+40S}$$

$$=\frac{N^2D^2k}{17.5(D+2.28S)}$$

$$N^2=\frac{17.5L(D+2.28S)}{D^2k}$$

$$N=\frac{\sqrt{17.5}\,\sqrt{L}\,\sqrt{(D+2.28S)}}{D\sqrt{k}} \quad .. \quad (4)$$

Comparing this with equation (3), it is seen that here also we can replace $\sqrt{L}$ with expression (1), so

$$N=\frac{4.18\left(\frac{159}{f\sqrt{C}}\right)\sqrt{(D+2.28S)}}{D\sqrt{k}}$$

$$=\frac{665\sqrt{(D+2.28S)}}{fD\sqrt{C}\sqrt{k}}$$

$$=\sqrt{\frac{665^2\left(1+2.28\frac{S}{D}\right)}{f^2CDk}} \quad .. \quad .. \quad (5)$$

Taking a final look round, we see there is $D\times k$ in the denominator, so we can expand this to:

$$Dk=D\left(\frac{D-2.25d}{D}\right)$$

$$=(D-2.25d) \quad .. \quad .. \quad .. \quad (6)$$

Inserting this expression in (5), we secure the submission hold:

$$N=\sqrt{\frac{665^2\left(1+2.28\frac{S}{D}\right)}{f^2C(D-2.25d)}} \quad .. \quad .. \quad (7)$$

It is interesting to review our handiwork. The equation (7) can be compared with (3), when it will be noticed that (D–2.25d) in the denominator of (7) takes the place of D in

(3) and that but for this difference, the two equations are similar. The virtue of reducing $\left(\frac{D-2.25d}{D}\right)$ to "k" for manipulation purposes is clearly seen. Not at all unlike a form of ju-jutsu, which is essentially knowing what holds to apply and when to use them.

The use of formula (7) can be demonstrated with a simple example.

**Example 2**

It is required to wind a coil ½in long on a ½in diameter former, the height of the winding to be 1/10in. The coil is to tune to 200 kc/s with 250pF. (Note here that 200 kc/s is 0.2 Mc/s). First of all convert the fractions to decimals: length of coil S=0.5in; depth of coil d=0.1in; outer diameter (i.e. inner diam.+twice d) is D=0.7in. Insert the known values in equation (7) and we have:

$$N=\sqrt{\frac{665^2\left(1+2.28\left(\frac{0.5}{0.7}\right)\right)}{0.2^2\times250\,(0.7-(2.25\times0.1))}}$$

$$=\sqrt{\frac{665^2\times2.63}{0.04\times250\times0.475}}$$

$$=\sqrt{\frac{665^2\times2.63}{4.75}}$$

=495 turns.

Using the necessary formula, the inductance of this coil is about 2,530μH. As a matter of interest, it is found to agree very closely with data evolved from the charts and formulae given in Langford-Smith's *Radio Designer's Handbook.**

It now remains to choose the size of wire. The winding is 0.5in long and 0.1in deep, so the cross-sectional area is 0.05 sq. in. The turns per sq. in. is thus 495/0.05=9,900. Taking the square root, this gives roughly 100 turns/sq. in. Either 36 s.w.g. SSC (105 turns/in.) or 37 s.w.g. DSC (102 turns/in) would be suitable. Other data would have to be consulted if it was necessary to use the optimum wire size for maximum Q.

**Conclusion**

There is no intention of claiming that a new method of calculating coil winding details has been evolved in this article. The writer's sole object has been to show the steps in developing an idea, and to present his findings in a way that he hopes makes a bit of maths a little easier (and maybe slightly amusing) to read.

* *Radio Designer's Handbook.* F. Langford-Smith B.Sc., B.E. (1st Class Honours), Senior Member I.R.E., (U.S.A.), A.M.I.E. (Aust.). Iliffe & Sons Ltd.

## *MEMO TO WIVES AND MOTHERS* by J. E. KITCHIN

*(Also, if applicable, to sisters and brothers and any other relative who thinks amateur radio men are "a queer lot.")*

Does "he" give you the "willies" with his fiddling around with his gear? Does he never get the contraption working to his satisfaction? Does he wake you up at 2 a.m. to the hilarious shout of "I've got Bongo-Bongo in south-west Africa!"?

If so, you needn't take any pills or potions, or even give him any. Just leave him alone, occasionally say "Oh, that's good," and go back to sleep. To help you out, here are a few rules which will, it is hoped, ease the strain of being a wife, mother, guardian, or what have you, of a radio enthusiast.

1. Don't keep asking when "it" is going to be finished unless he mentions the subject first.

2. Don't even ask if it is *ever* going to be finished—it might never be! (That's part of the fun. In case you haven't already found out, nothing was ever made to the complete satisfaction of a radio man.)

3. Don't object to the hobby too strenuously; at least you know where he is at night.

4. If you like his company and the gear is in the cellar, why not suggest a small set upstairs? Lots of radio men have transmitters and receivers in boxes no larger than your sewing basket—and they make good "conversation pieces" too.

5. Don't ever suggest that he spends so much time with his gear that he hasn't the time to fix the fence, toaster, vacuum cleaner, washing machine, paint the room, mow the lawn, or take you out. Simply say off-handedly, "Now that reception conditions aren't too good, why not fix the fence to give you something to do?" (You can't possibly get caught in a jam with this one because reception conditions are always bad on some frequency or other).

6. Puzzled over what to give him for Christmas, birthday, or an anniversary, or a present for no good reason at all? Just look casually at some of his catalogues and say: "That's a nice (substitute neat, queer, odd, awful—as required) looking thing, what does it do?" You'll get your answer! (Caution! Look at the price first and if it is a foreign catalogue mentally add enough to cover import duty and shipping charges.)

7. Show this last suggestion to HIM. Why don't you fix the blinking fence or whatever it is? You've got lots of time and you can finish that wiring job tomorrow—it will give you something to look forward to, and remember that Amateur Radio is a hobby.

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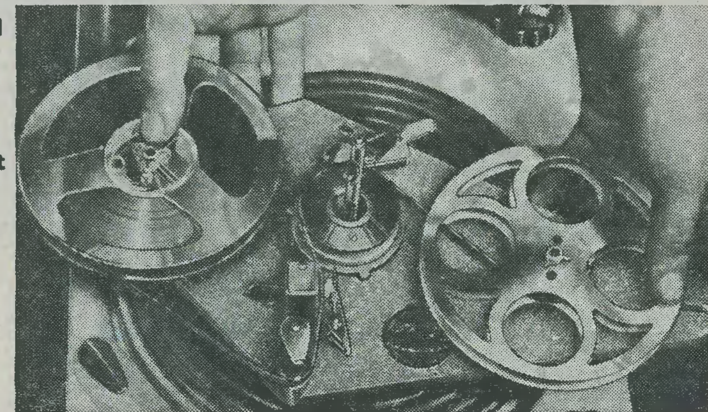

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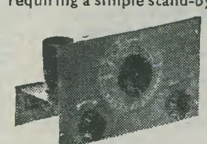

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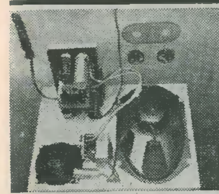

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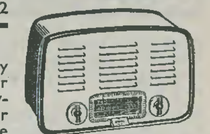

Battery Receiver for only **£4.19.6** plus 5/– p. & p., or **£1** deposit and 5 monthly payments of **19/–**. This receiver is ideally suitable for use in the home or where normal electricity supply is not available, remarkable reception on both medium and short wavebands, incorporating the following latest type miniature battery valves: DK92, DF96, DAF96, DL96, and operates on an external B103 battery or equivalent. It is housed in an attractive two-tone metal case. Size 11½" x 7½" x 5¼". Battery EXTRA, **18/6.**

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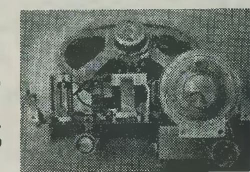
Complete with Test Leads **£4.19.6** p. & p. 2/6

**THE COSSOR**
**Printed Circuit Model**
**701K VHF/FM Radio Receiver Kit**
Original Price 15 Gns.
**Our Price £8·19·6**
P. & P. 2/6



This Kit can be easily assembled and will provide a complete radio receiver for reception of transmission employing f.m. radiating from the VHF transmitters. This receiver utilises the latest type printed circuit method and is suitable for use on a.c. or d.c. mains. The Kit is supplied complete in every detail including a 10" x 6" Goodmans loudspeaker.

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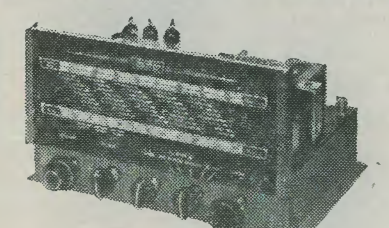

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This is the famous Cossor 562K, 3-watt Audio Amplifier Kit, using 1 EF86, 6BQ5 and 5V4 valves, a 10" x 6" elliptical speaker and a 4" round speaker. This kit can be easily assembled to provide a compact and versatile printed circuit amplifier suitable for operation from radio microphone gramophone inputs. The circuit design includes negative feed-back and high performance loundspakers, an easy-to-build instruction pamphlet. Original list price £9.15.0.

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### VHF Radio Receiver Kit

This again is the famous Cossor printed circuit model 701/K. The kit may easily be assembled to provide a complete radio receiver suitable for the reception of transmissions employing f.m. (frequency modulation) radiating from the v.h.f. (very high frequency) transmitters now serving many different parts of the country. All parts, including loudspeaker and valves, are provided, together with the building instruction book.

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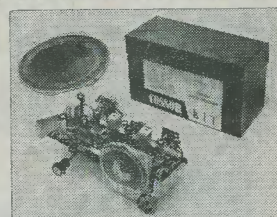
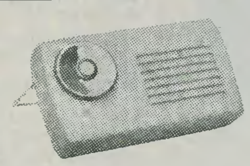


**OUR PRICE £8·19·6** *P. & P. 2/6*



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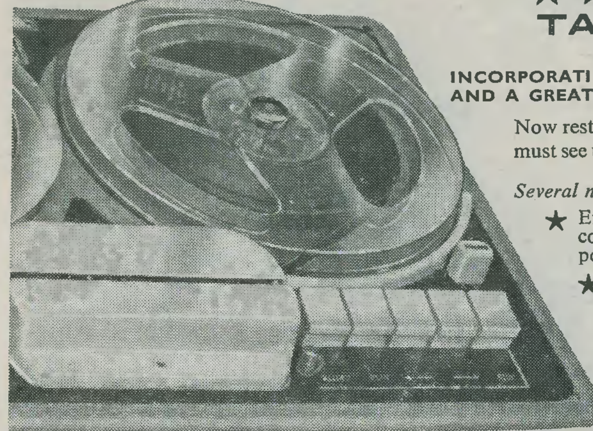

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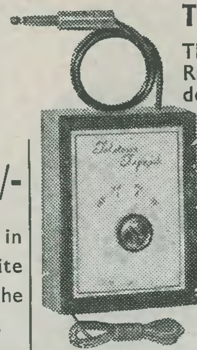

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| 1S5 | 7/6 | 6X4 | 7/6 | DH77 | 7/6 | EL41 | 9/– |
| 1T4 | 6/– | 6X5G | 7/6 | DK91 | 7/6 | EL84 | 10/6 |
| 3S4 | 7/6 | 12AH8 | 10/6 | PY82 | 7/– | EL91 | 7/6 |
| 3V4 | 8/– | 12AT7 | 7/6 | DK96 | 8/– | EY51 | 9/6 |
| 5U4G | 7/6 | 12AU7 | 7/6 | DL92 | 7/6 | EZ40 | 6/6 |
| 5Y3GT | 8/6 | 12AX7 | 9/– | DL94 | 8/– | EZ80 | 6/6 |
| 5Z4G | 9/– | 12BH7 | 10/6 | DL96 | 8/– | EZ81 | 7/– |
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| 6AL5 | 5/6 | 12K8GT | 13/6 | EBC41 | 9/6 | PL82 | 10/6 |
| 6AT6 | 7/6 | 12Q7GT | 8/6 | EBF80. | 10/6 | PY81 | 8/– |
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| 6BE6 | 7/6 | 25L6GT | 9/– | ECC82 | 7/6 | PCF80 | 10/6 |
| 6BR7 | 10/6 | 35Z4GT | 8/6 | ECC83 | 7/6 | PCF82 | 11/– |
| 6BW6 | 8/6 | 35L6GT | 9/6 | ECC84 | 10/6 | PCL82 | 10/6 |
| 6J5G | 5/6 | 53KU | 11/6 | ECF82 | 11/– | U76 | 8/6 |
| 6J7GT | 8/6 | 807 | 6/9 | ECH81 | 10/6 | UBC41 | 10/– |
| 6K7G | 7/6 | 5763 | 10/6 | ECH42 | 8/6 | UCH42 | 10/6 |
| 6Q7G | 8/6 | DAF91 | 7/6 | ECL80 | 9/6 | UF41 | 10/– |
| 6SL7GT | 8/– | DAF96 | 8/– | EF41 | 8/6 | UL41 | 8/– |
| 6SN7GT | 8/6 | DF91 | 7/6 | EF80 | 8/– | UY41 | 8/– |
| | | DF96 | 8/– | EF91 | 6/9 | W76 | 8/6 |

**Matched Pairs.** EL84, **23**/–; 6V6G, **17**/–; 6BW6, **18**/–; KT33C, **19/6**; KT66, **27/6**; 807 **14/6** pair

1R5, 1S5, 1T4, 3S4, 3V4, DAF91, DF91, DK91, DK92, DL92, DL94, any four, **27/6** per set

**P.P. Op. Transformers.** MR 3–15 ohms for EL84, 6V6, 6BW6, etc, **18/6**; Op. Pen. 50mA, **5/6**; 30mA, **4/6**

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**W.W. Pots.** Pre-set **3/–**, 3W long spindle **5/6**, s.p. **6/6**

**P.M. Speakers.** 3 ohm. 5″ **16/6**, 6½″ **17/6**, 8″ **21/–**, 10″ **25/–**, 12″ **30/–**, Bakers 12″ 15 ohm 15W, **90/–**

**Coaxial Cable.** 75 ohm ¼″ stranded, **8d.** yd; semi-air spaced, **9d.** yd; screen cable single and twin, **9d.** yd

**Coaxial Plugs 1**/– each; **Sockets 1**/– each

★ **C.R.T. Isolation Transformers** with nil, 25% and 50% boost, low capacity a.c. mains 200/250V for 2V 4V, 6.3V and 13V tubes. All **10/6** each

**Valveholders.** 4, 5, 7 pin English and U.S.A. B7G, B9A, 10, M0, B8G, **9d.** each; B7G, B9A with screening can, **1/6**; B12A, **1/3**. Aladdin formers ¼″ with core, **8d.** each

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**I.F. Transformers,** 465 kc/s, small size, **7/6** pair

**Capacitors,** small mica, 5% 1pF to 100pF, **8d.**; 120pF to 1,000pF, **9d.**; 1,000V wkg. .01, .0015, .0025, .004, .005µF, **1/–** each

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**Headphones,** lightweight, 4,000 ohm, **16/6** pair

**Ceramic Capacitors,** close tol. 500V for V.H.F., **9d.**

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**Resistors,** ¼ and ½W, insulated, **4d.** and **6d.**; 1W, **8d.** 6W W.W., **1/–**; **10W, 2/–**

**Electrolytics.** Wire ends. 25/25V, **1/6**; 50/50V, **2/–**; 12/50V, **9d.**; 8/450V, **2/–**; 16/450V, **2/9**; 16/500V, **3/6**; 32/450V, **4/–**; 8+8/450V, **4/6**; 8+16/450V, **4/6**; can types: 16/450V, **3/6**; 16+16/500V, **6/–**; 32/500V, **6/6**; 32/450V, **6/6**; 20+20/450V, **4/6**; 64+120/275V, **7/6**

**Wavechange Switches,** midget: 1p 12W, 2p 6W, 3p 4W, 4p 3W, 4p 2W, long spindles, **4/6**

**Toggle Switches.** QMB, s.p.s.t., **2/–**; s.p.d.t., **3/3**; d.p.s.t., **3/6**; d.p.d.t., **4/–**

**Chokes,** 80mA, 15H, **8/6**; 100mA 10H, **10/6**; 150mA 10H, **14/6**

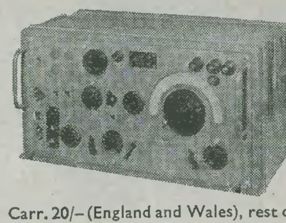
★ **Solder, Multicore, 4d.** yd; Sleeving 2mm, **3d.** yd

*P. and P. 9d. to £1; 1/6 to £2; over £2 post free. C.O.D. 2/6*

**R. COOPER** G8BX **32 SOUTH END CROYDON SURREY** CROYDON 9186



## ALL BAND RECEIVER R107
**AMATEUR—SHIPPING—BROADCAST**



This magnificent 9-valve 3-wave band receiver gives world-wide reception over 1.2–17 Mc/s (18–250 metres). The sensitivity is 1 microvolt on C.W., and 2–6 microvolts on R.T. Panel controls include Bandwidth switch ("Wide" or "Narrow"), choice of AVC and BFO, Audio Filter, R.F. Gain, Aerial Trimmer. Has built-in Output stage with internal speaker. Headphones sockets. Incorporates internal A.C. mains power unit (100–250V A.C.) and 12 volts D.C. Vibrator pack. Size 24″ x 13″ x 17″. These sets are extensively tested prior to despatch.

*SUPPLIED COMPLETE AND READY FOR IMMEDIATE USE*

MODEL 1. Slightly used appearance **£8.10.0** MODEL 2. Very good appearance **£10.10.0** Carr. 20/– (England and Wales), rest of U.K. extra.

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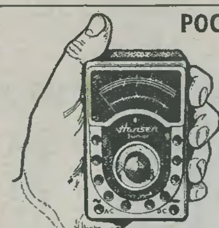
*All kits supplied entirely complete with full wiring and assembly details. Fully guaranteed*

## POCKET MULTI-METER



2,500 o.p.v. Multi-range. 6/30/120/300/1,200V a.c., ditto d.c. 0–1kΩ, 0–1 MΩ; 400µA, 12mA, 300 mA; —00 to +64dB; 5 ranges. 3″ x 4½″ x 1¼″. Large clear dial, leads. List price £6.19.6. OUR PRICE **£4.7.6**, P. & P. 2/6. Saving you £2.13.0.

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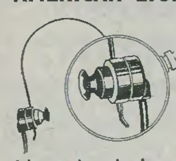

*They're High & Low Impedance!* These H.S.30 phones are the finest used by the U.S. Air Force. 250Ω imp. using soft rubber miniature ear moulds for maximum music and voice reproduction of the finest quality. Supplied free is a small transformer unit with cord and plug which steps impedance up to 4,000Ω. ONLY **15/–**, P. & P. 2/6.

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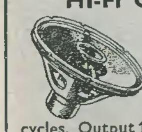

BRAND NEW—U.S.A. MADE. 12″ Coaxial Speaker. The woofer uses 6.8oz Alinco 5 magnet. Has 3″ tweeter and an electronic crossover network to separate the speaker functions. Freq response: 40–17,000 cycles. Output 12 watts, imp 8 ohms. ONLY **120/–**. 8½″, 2½″ tweeter, 10 watts, etc., **90/–**. P.& P. 4/– on each.

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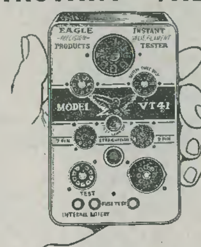


**MODEL VT-41**

*Pocket size*
*Battery operated!*
*GIVES INSTANT CHECK of*

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*International octal, B8A, B9A, B7G battery and mains types.

- Has built-in miniature 7 and 9 pin valve straighteners and battery test.

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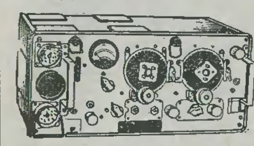

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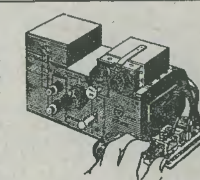

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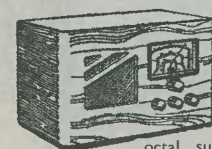

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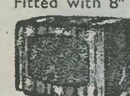

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*continued on page 319*

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