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1960

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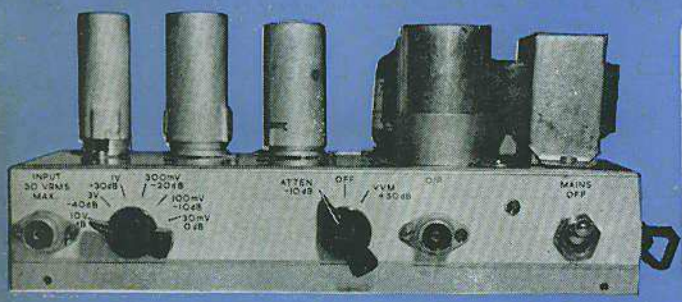

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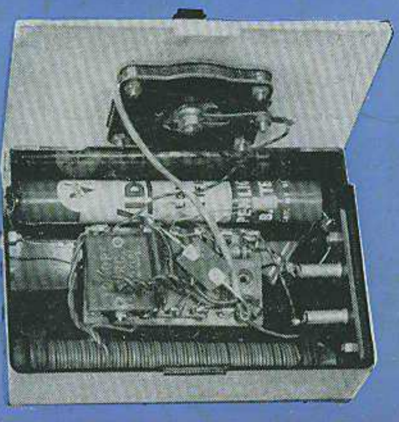

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Printed by A. Quick & Co. (Printers) Ltd 125 High Holborn London WC1 England *also* at Clacton-on-Sea
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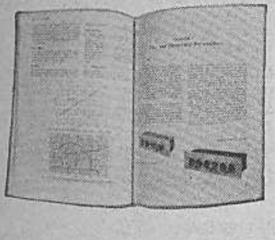

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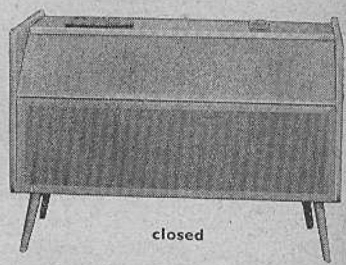

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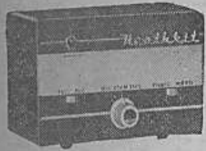

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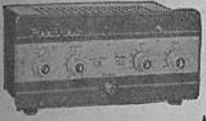

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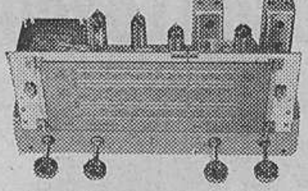

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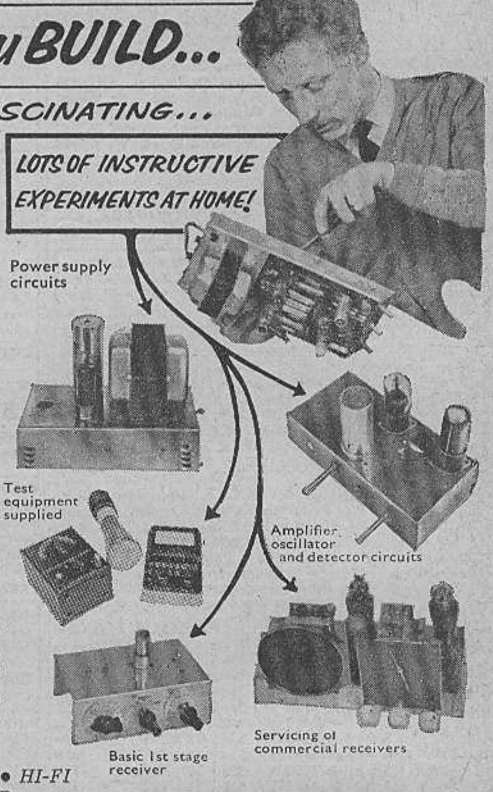

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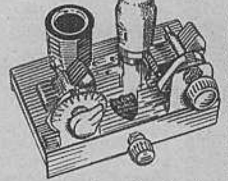

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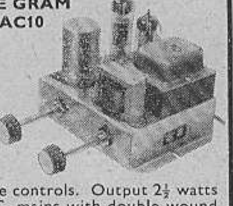

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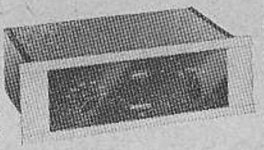

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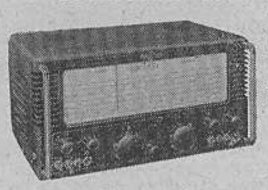

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The

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Vol. 13 No. 7 FEBRUARY 1960 ANNUAL SUBSCRIPTION 25/- (*including postage*)

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CONTENTS

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ARTICLES appearing in this magazine which describe kits are inserted only on condition that such kits, or special components thereof, are freely available at a trade discount to all retail advertisers.

OPINIONS expressed by contributors are not necessarily those of the Editor or proprietors.

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.

ALL MSS must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and address.

TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

TECHNICAL QUERIES should be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

ALL CORRESPONDENCE should be addressed to THE RADIO CONSTRUCTOR 57 Maida Vale London W9.
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RADIO

No. 111 An Improved-Quality Outlet for A.M. Receivers

Suggested Circuits

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

OVER THE PAST YEAR OR SO, THE WRITER has received several letters from tape recorder enthusiasts who have attempted to record broadcast programmes with the aid of medium and long-wave radio receivers, and who have been dissatisfied with the resultant sound quality. In most cases the tape recorders were fed directly from the second detector diode load, and, so far as could be ascertained, presented input impedances which were sufficiently high to avoid seriously upsetting the a.c./d.c. load ratios in the receivers. Some of the writer's correspondents have asked whether it would be possible to change the receiver circuitry such that an a.f. outlet providing much higher quality could become available for recording purposes.

The short answer to this question is, of course, that the only way of obtaining broadcast programme material at really good fidelity consists of employing a v.h.f. tuner or receiver. The crowded and chaotic conditions on the medium wave band make it necessary for a.m. receivers to have i.f. response curves which give heavy attenuation of sidebands above 4 kc/s or so; and the resultant short-comings in audio response become particularly noticeable when a.f. from such receivers is fed to tape recorders with reasonably good performance. However, a short answer of this type is not liable to satisfy those recording enthusiasts who intend to record broadcast material at infrequent intervals only, and who do not feel that the cost of an f.m. tuner is thereby justified. The writer decided, therefore, to devote an article to this particular problem, assuming that it would be of assistance to those who can receive the desired programme without excessive adjacent channel interference and the like.

This month's suggested circuit deals with a small add-on unit which may be permanently fitted to any conventional a.m. superhet and which provides detected a.f. having a frequency response which is better than that available from the second detector. The add-on unit should not noticeably affect the performance of the receiver, and the latter may be operated in exactly the same manner as it was before modification. If desired, indeed, the tape recorder can be connected to the special outlet provided by the unit whilst the set is being used in normal manner. It is possible that the add-on unit may cause a slight reduction in the overall selectivity of the receiver, but this effect should be almost negligible.

The add-on unit functions with the signal which is available at the grid of the i.f. amplifier valve. This signal will have been passed through one i.f. transformer only, with the result that the higher frequency sidebands will have suffered less attenuation than occurs when the signal has been passed through the two i.f. transformers. In consequence, the add-on unit will provide an audio signal which has a markedly better response than that available at the second detector diode.

The Circuit

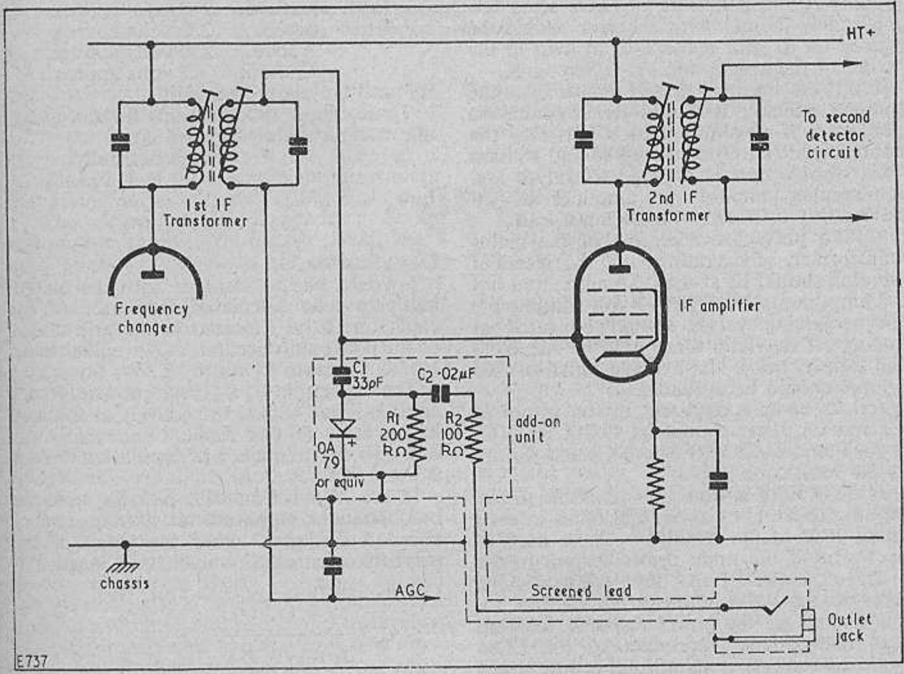
The circuit of the add-on unit accompanies this article. It consists basically of a shunt detector coupled to the i.f. amplifier grid via the 33pF condenser C_1. The detector is a germanium diode, and the diode load is provided by R_1. The blocking condenser C_2 prevents the rectified d.c. component from reaching the outlet terminals, whilst R_2 functions as an i.f. decoupling resistor. The decoupling capacity which would normally follow R_2 is provided here by the self-capacity of the screened cable which couples the add-on unit to the tape recorder.

In order to prevent instability the unit is fitted into a completely screened box.

as possible, and the lead to this grid should be kept well away from the i.f. amplifier anode wiring. The unit should, also, be earthed to the chassis at a point close to the i.f. amplifier valve. The screened cable from the unit may travel over any convenient route to the output jack, it being presumed that the latter will be mounted at a convenient point at the back of the receiver. In order to prevent instability and hum pick-up, the jack should be screened.

Technical Details

It is difficult to state the output level to be expected from the unit owing to the obvious discrepancies in performance given by the various receivers into which it may be fitted. Speaking in very general terms, an output of some 50mV or so should be expected. As a rough guide it may be stated that the output will be well in excess of that provided by a plug-in "radio-jack".



Practical Points

Few difficulties should be encountered in constructing the add-on unit. The few components required take up little space, and it should be possible to make the screened box into which they are fitted correspondingly small in overall dimensions. The unit should be mounted as close to the i.f. amplifier grid

To prevent distortion on heavily modulated signals, the impedance into which the add-on unit feeds should be at least 500kΩ. If the input impedance of the particular recorder with which the unit happens to be used is lower than 500kΩ, but above 100kΩ, the difference may be made up by a series resistor inserted in the non-earthy lead at the recorder end of the screened cable. Thus, if the input impedance is 250kΩ, then a series resistor of 250kΩ should be added. The additional resistor will, of course, give an inevitable drop in signal level.

It was stated above that the add-on unit will slightly affect the selectivity of the receiver to which it is fitted. This is due to the fact that it will cause slight damping of the first i.f. transformer secondary. There will, also, be some slight detuning of this secondary when the unit is initially fitted. After the unit has been connected up, therefore, it will be necessary to slightly re-trim the first i.f. secondary coil.

"Transformerless" Receivers

Before concluding, it should be pointed out that, due to the difficulty of obtaining adequate mains isolation without the introduction of hum into the low-level signal provided, it is *not* recommended that the unit be fitted to any receiver whose chassis is connected to one side of the mains supply.

●~~~ From our Mailbag ~~~●

DEAR SIR,

On reading the latest (Dec. '59) copy of your journal, I noted the circuit for "A Good Quality Audio Amplifier". There are a few misleading points which I feel should be passed on to your readers, or at least to the writer of the article, Mr. A. J. Sercombe.

(*a*) If the amplifier is used remote from the volume control, it would be advisable to connect a 1-megohm resistor between the control grid (pin 9) of the EF86 and chassis. This would prevent damage to valves and loudspeaker, should the amplifier be inadvertently operated with no input lead.

(*b*) To prevent overheating of the mains transformer, the rating of the rectifier winding should be at least 0.6 amp., and not 0.3 amp. as stated. The 6.3-volt winding for the remaining valves should be rated at 1 amp. if no radio tuner is to be run from the supply, but if the average tuner is used 3 amp. should be available.

(*c*) An error is apparent in the values of C_8 and C_9, these should no doubt read C_8 is 50μF and C_9 is 50μF; both C_8 and C_9 are in the same can.

If C_9 is 50μF it would be advisable to put limiting resistors of about 120 ohms in each anode lead of the rectifier. These need to be 1 watt if the tuner draws current in the order of 40mA. I feel that there is some error in the voltages measured on the h.t. line and to get the power response required with high quality reproduction, the EL84 could be run nearer its normal rating. Even with a tuner consuming 40mA and the amplifier drawing a further 40mA the voltage at the cathode of the rectifier will be about 270 volts. The smoothing resistor R_8 may well be increased to 1,000 ohms at 4 watts and then the output transformer primary should be taken from the cathode of the rectifier. This will prevent the EL84 screen grid potential from exceeding that of the anode. To reduce hum R_2 can be increased to 56,000 ohms.

The voltage table should now read:

EZ80	Cathode	270 volts approx.
EL84	Screen	220 volts approx.
	Anode	250 volts approx.
	Cathode	7 volts approx.

R_7 need only be $\frac{1}{2}$ watt rating.

These simple modifications should greatly improve results at no extra cost.

Yours faithfully,
P. J. FARROW.

Ipswich, Suffolk.

DEAR EDITOR,

I would like to disagree with the mathematician who calculated the value of the capacitor (0.3μF) located in the grid circuit of the phase shift oscillator (November issue, No. 4, "Vibrato" Unit, by E. W. Bones).

The capacitors $C_{a\,b\,c}$ and resistors $R_{a\,b\,c}$ are 0.3μF and 680kΩ respectively as specified in my issue of *The Radio Constructor*, this being so the frequency of oscillation will be 0.3 c/s, and not 3 c/s.

If the signal from the pick-up is to be modulated in amplitude at a frequency of about 3 c/s, then either the value of the resistors or capacitors must be changed.

Let $R_a = 680\text{k}\Omega$ and $f_o = 3$ c/s; then

$$C_a = \frac{1}{f_o\, 2\pi\sqrt{6}\, R_a}$$

$$\text{or } C_a = \frac{1}{3 \times 2 \times 3{\cdot}142 \times \sqrt{6} \times 680{,}000}$$

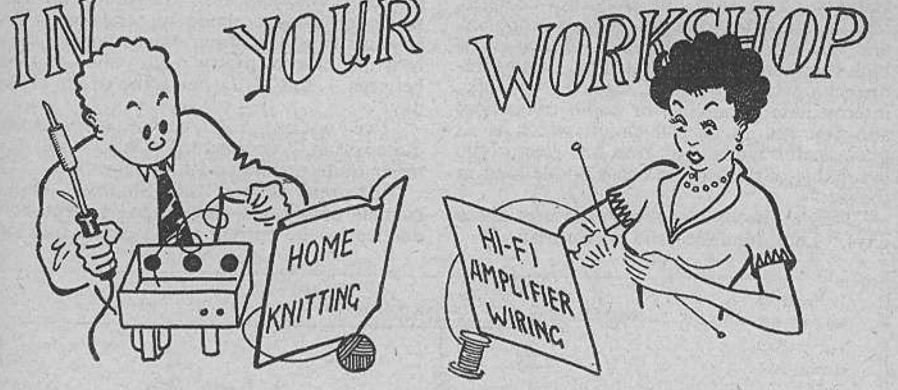
$$\therefore\ C_a = 0.03\mu\text{F}$$

Apparently the mathematician has dropped or lost a decimal point somewhere!

Yours faithfully,
D. ASTON.

Spennymoor, Co. Durham.

IN YOUR WORKSHOP



This month Smithy the Serviceman and his able assistant, Dick, shelter from the vagaries of the weather and discuss ways and means of improving sound and television receivers

“BUT YOU'VE *always* SAID,” DICK expostulated, “that the prime object of servicing is that of restoring the receiver to the condition it was in when it left the factory. Now you're recommending alterations and additions!”

“The prime object of servicing *is* to restore the receiver to factory condition,” said Smithy. “But there are exceptions to every rule.”

“Well, I can't help but feel unhappy about this particular exception,” remarked Dick obstinately. “In the past you've always ticked me off whenever I started making alterations to receiver circuits during servicing.”

“Ah, yes,” replied Smithy, “but *your* alterations involving building new sets altogether! What about that four-plus-one superhet which had low gain?”

Dick winced. Smithy's words had touched a raw point.

Because of a sudden decision by whatever whimsical beings there be who control Britain's weather, Smithy the Serviceman and his assistant Dick had found themselves virtually imprisoned in the Workshop after work had finished for the day. For some twenty minutes or so they had sat glumly watching monsoon-like rain beating against the windows, and had waited fretfully for a break in the downpour so that they could make a dash for Smithy's car parked some distance away, and thereby wend their way homewards. During their enforced stay in the Workshop they had indulged in a desultory conversation which had ranged from the latest “pop” tunes released by the record companies (in which Smithy was not in the slightest bit interested) to a stirring account of Smithy's experiences during the war (of which Dick did not believe a single word).

They had inevitably ended on the only subject in which they shared a common interest.

Alterations and Improvements

“Well, I suppose that adding an extra valve between the double-diode-triode and the output pentode *was* a little ambitious,” conceded Dick, selecting his adjective with some care, “but you must admit that it did bring up the gain.”

“I'll say it did! When, that is, you could hear the audio through the motor-boating which resulted from hitching your additional valve straight on to the h.t. positive line without any additional a.f. decoupling *anywhere* in the set.”

Dick gave an embarrassed grin.

“You know,” he said, “I've quite forgotten what the original fault in that set was, now.”

“It was one,” said Smithy sternly, “which you should have spotted straight away. The screen-grid decoupling condenser on the i.f. valve had sprung a leak, and it had dragged the screen-grid potential down to some 20 volts or so. With the result that the poor i.f. bottle was trying to work at quarter-cock only.

“However, that's not the point. What I objected to mainly was your adding an extra a.f. stage to a thing like a four-plus-one. The four-plus-one, four valves and a rectifier, has become as popular as it now is in domestic sound radios because of its inherent stability. You have one frequency-changer, one i.f. amplifier, one a.f. voltage amplifier, and one a.f. output amplifier. There is no high-level amplification at any single frequency, whether it be signal frequency, intermediate frequency, or audio frequency; and you get an overall circuit which is so intrinsically stable that one h.t. electrolytic is capable of decoupling every anode load in the set."

"They're becoming three-plus-ones these days," Dick reminded the Serviceman.

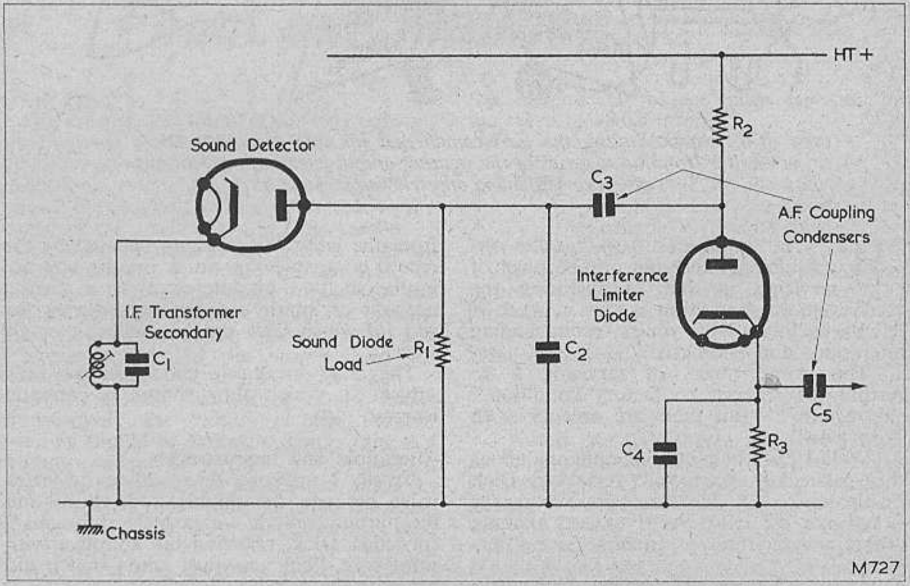


Fig. 1. A typical sound interference limiting circuit, as employed in television receivers. Of R_2 and R_3, either one or both may have the high value referred to by Smithy. Valve diodes are shown here as they help to illustrate operation, but germanium diodes are employed in most practical circuits

"That's true enough," conceded Smithy. "Many of the less expensive sound radios are now combining the a.f. voltage amplifier and the output valve in a single envelope.

"Anyway, let's get back to what started off the argument just now. All that I uttered was a mild and fleeting observation to the effect that it was sometimes possible to improve receiver performance by making slight alterations to circuitry or components."

"Nevertheless," said Dick pompously, "I feel that, in the light of my previous experiences, I must press for an example."

"Very well," said Smithy, "I'll give you a very simple instance right away. As you know, most t.v. receivers employ a sound limiter circuit just after the sound detector which contains a diode in series with two resistors (Fig. 1). Either one or both of these resistors has a pretty high value, figures between 1 and 4MΩ being the order of the day."

"I've noticed that circuit arrangement quite often," commented Dick, "but I've never quite understood how it works."

"It's pretty simple," said Smithy. "Under normal conditions the diode is kept conductive by the current which passes through it via the two resistors (R_2 and R_3 in Fig. 1). In the conductive state, the diode allows a.f. from the detector to be passed on to the subsequent a.f. amplifier grid. If a heavy pulse of interference is picked up by the receiver this is rectified by the sound detector, and is passed to the noise limiter diode in the form of a negative-going pulse which causes the anode of the diode to go similarly negative. The cathode of the diode wants to go negative also, but it can only do this at a slow rate because of the cathode condenser (C_4). So the diode becomes cut off, with the cathode dropping slowly in potential as its condenser discharges into the parallel resistor. The interference pulse comes to an end well before the diode cathode potential has dropped by any significant amount, whereupon the diode becomes conductive once more, and passes a.f. again in normal manner."

"I see," said Dick, thoughtfully. "Could I sum it all up by saying that the diode cuts off during most of the interference pulse, with the result that the pulse doesn't get through to the a.f. amplifier stages?"

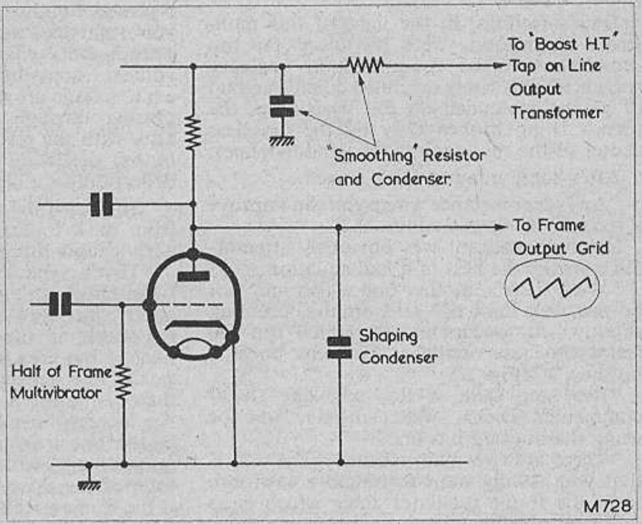


Fig. 2. Running the frame oscillator from the boosted h.t. line. In this diagram the triode is half of a frame multivibrator and, when it is "on," it causes the shaping condenser to discharge rapidly. When the triode is "off" the condenser charges up slowly via the anode load resistor

"That's right. A little bit of the pulse, *that* needed to cut off the diode, gets through, and that is all. The remainder of the pulse is lost, and the audible effect of the interference is considerably reduced as a result."

"Well, I must say it all sounds very reasonable! I presume that the resistor and condenser in the cathode are such that they have a time constant which is a lot longer than the anticipated pulse length, but which does not introduce the risk of causing too much top-cut."

"Correct."

"Also I notice," continued Dick, "that you've included the sound detector diode in your sketch."

"That's because," remarked Smithy, "it plays rather an important rôle in the operation of the circuit."

"It's stopped raining," interrupted Dick, standing up quickly.

"O.K.," said Smithy. "Let me just finish my explanation and then we'll go. If the limiter is to operate, it's essential that the rectified interference pulse from the sound detector be negative-going. So it is important to connect the sound detector right way round."

"Hurry up, Smithy," said Dick, impatiently, "it's already started to cloud over again."

"And that is why," concluded Smithy, inexorably, "you should never listen to people who say that the sound detector diode in a t.v. set may be connected up any old way. If you connect it the wrong way round you are liable to stop the interference limiter from working."

Dick was now standing restlessly at the Workshop door.

"Having explained how the limiter works," continued Smithy, completely lost in his subject, "I'll get back on to this business of improving a receiver by alteration. One of the most common faults in a t.v. receiver is that the high-value resistors which keep the sound interference limiter diode conductive go open-circuit after a period of time. Part of this is due to the fact that many manufacturers fit fiddling little components in these positions which, whilst perhaps being theoretically up to the job they have to do, frequently fail to meet their commitments satisfactorily in practice. So, whenever you get a set in for repair in which a high-value interference limiter resistor has gone o/c, it's always a good plan to fit a replacement component having a wattage rating which is double that of the one which has gone phut."

Smithy looked around at his assistant, and was surprised to see him slumped in his chair, gazing despondently at the windows. Following his glance, Smithy saw that the rain was now pelting down heavier than ever.

"Why, you silly chump," exploded the Serviceman. "It's started raining again! We'd have got away just now if you hadn't held me back with your questions!"

Frame Bounce

Dick's feelings, in the light of this monstrous accusation, were obviously far too tumultuous to be committed to ordinary speech, and he wisely remained quiet. A cloud of gloom descended on the Workshop, the silence being broken only by the ceaseless clatter of the rain against the window panes.

After some minutes Dick stirred.

"Any other instance where you can improve a receiver by simple additions?"

Smithy's assistant was obviously attempting to make the best of a bad situation.

"Well, there's another one which may not be too well known," said Smithy, cheering slightly. "It occurs in sets which run the frame timebase oscillator from the boosted h.t. line." (Fig. 2.)

"I've seen quite a few sets like that," commented Dick. "What's the reason for using the boosted h.t. line?"

"There are two main reasons. The first is that you usually want to obtain a sawtooth from the frame oscillator stage which is as linear as possible. If you connect the valve which provides the sawtooth to an h.t. line which is much higher in voltage than the normal h.t. line your chances of getting a linear sawtooth increase in proportion. The reason being that the shaping condenser has to charge over less of its total exponential curve for the same amplitude output.

"The second reason for running the frame oscillator from the boosted h.t. line is probably more important, and it has to do with stabilising of picture height. As you know, it's rather a difficult problem to design an e.h.t. supply for a domestic television receiver which offers perfect voltage regulation."

"Which means," chimed in Dick, "that as the current drawn from the e.h.t. supply increases its voltage output drops."

"That's right," said Smithy. "Now, the current drawn from the e.h.t. supply is continually changing. If the scene depicted on the cathode ray tube screen is of a dark character, only a small amount of e.h.t. current is drawn. If the scene is of a bright character, the current drawn is very much higher. Due to these varying currents you have the effect wherein the e.h.t. voltage applied to the c.r.t. final anode is high for dark scenes and is low for bright scenes."

"Aren't changes in final anode voltage liable to cause defocusing?"

"There will be a light defocusing effect," agreed Smithy, "although it shouldn't to too obvious in most cases. What is liable to be far more noticeable is the fact that the *size* of the picture may vary."

"Hey?"

"The size of the picture may vary," repeated Smithy. "I don't need to remind you of the well-known 'blooming,' or opening-out, effect which occurs if e.h.t. voltage drops by a large amount. When e.h.t. voltage drops, the speed of the electrons passing through the deflector yoke drops also, with the result that they remain longer in the deflection fields and undergo more deflection."

"So that, if the scene on the screen changes from dark to bright, the resultant drop in e.h.t. causes the picture to become bigger?"

"That's about it," confirmed Smithy. "The effect isn't too bad if the set has got good e.h.t. regulation, and is rendered less noticeable if the edges of the raster are outside the area seen by the viewer. So far as the line deflection circuits are concerned there is, also, a self-compensating action. An increase in e.h.t. current causes a drop in the boost voltage developed by the line output stage, with the result that you lose a little of the drive to the line deflector coils. If the frame oscillator is run from the normal h.t. line, however, this self-compensating action doesn't take place."

"I see," commented Dick, pensively. "So we get the situation where, with a poorly regulated e.h.t. supply, the line width remains more or less the same when you change from a dark to a bright scene, but the frame height is liable to increase."

"Exactly!"

"Your next step," said Dick, quickly, "is, therefore, to run the frame oscillator from the boosted h.t. line as well. Then, when the bright scene appears and e.h.t. drops, the consequent drop in boost voltage causes the frame sawtooth amplitude to drop as well. So that the frame height becomes self-compensating in just the same manner as does the line width."

"That's my boy!" remarked Smithy, pleased. "You've got it 100% right. And *that's* the second reason for running the frame oscillator from the boosted h.t. line.

"Now for the snags," continued the Serviceman. "As you are porbably well aware, frame oscillator stages are not very easy to synchronise. This is partly because of the method of obtaining the frame sync pulse from the signal. A further point is that it is usual to give the frame oscillator just enough sync coupling to enable it to lock, since it is otherwise liable to be triggered by odd bursts of interference. The frame oscillator is, therefore, always very sensitive to changes in operating conditions, including changes in its h.t. supply. If the frame oscillator runs from the boosted h.t. line, its operation is liable to be quite noticeably upset if the boosted h.t. line potential changes rapidly when you go from dark to bright scenes. Or vice versa. You are then liable to get the very annoying effect where the frame 'bounces' on camera change at the transmitter, or, even, where the frame loses lock altogether on camera change."

"What's the solution?"

Smithy looked up suddenly and, ignoring Dick's question, rushed to the door.

"Come on," he called out, "it's stopped raining again!"

But Dick was lost in contemplation of frame bounce.

"Just a moment," he said. "What's the solution?"

"The solution? Oh, to make certain that the changes in boosted voltage aren't too rapid," said the Serviceman. "The boost supply will almost certainly be 'smoothed' by a resistor and condenser (Fig. 2); so all you have to do is to make the smoothing condenser fatter. Come on, hurry up!"

"But the condenser's liable to be pretty large in value already," persisted Dick. "Most sets I've seen which run the frame oscillator from the boosted line give the smoothing condenser a value of 0.1 to 0.25μF."

"I know they do," said Smithy, fretfully. "But you can still up it to 1μF or so."

"At five to six hundred working volts?"

"Yes, yes," snapped Smithy. "Such condensers are available. Look, let's get going before the rain starts again!"

"How about two 2μF units of lower working voltage in series?" asked Dick, determined to pursue the subject to its conclusion.

"If you use two condensers in series you should put equal-value resistors across them. (Fig. 3.) I would say for this application you would need two 2MΩ resistors."

"Whatever for?"

"Because," said Smithy, almost grinding his teeth with frustration, "if you don't, the d.c. voltage across each condenser may not be equal. If one condenser had a leakage resistance of 100MΩ, and the other a leakage resistance of 500MΩ, then, without the resistors, one condenser would have one-sixth of the total voltage appear across it, and the other five-sixths."

"I see," commented Dick, completely oblivious of the Serviceman's feverish desire to reach his car. "So, if you want to put two condensers in series to get twice the working voltage you need to connect equal value resistors across them which are much lower in value than what you would expect their leakage resistances to be."

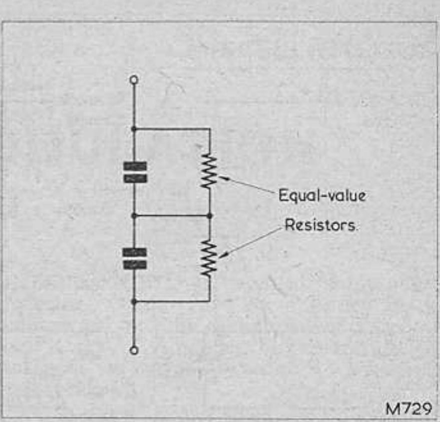


Fig. 3. If two similar condensers are connected in series to obtain twice the working voltage, equal-value resistors should be connected across them. This ensures that the total voltage is divided equally between the condensers. The resistors should have values markedly lower than the anticipated leakage resistances of the condensers

"You've got it," Smithy growled, from the doorway. "The figure of 2MΩ I just recommended is a little higher than you'd normally use for a job of this nature, but in this case you don't want to draw too much current from the boost line. Now, please, *please*, let's get going!"

"Just one more question," said the insatiable Dick. "Does your idea of putting extra smoothing on the boost h.t. supply clear *all* cases of frame bounce, or slip, on camera change?"

"Not all. Because the trouble may be caused by a basic fault in the frame sync circuits. But it *has* worked in quite a number of the cases that have been through my hands. Now come on!"

"Right," Dick said briskly, and he rose from his seat. As he walked to the door he saw Smithy's arms drop to his sides in a gesture of long-suffering despair.

"You might as well sit down again," said the Serviceman resignedly. "The rain's started again!"

Other Additions

The atmosphere in the Workshop for the next few minutes was the frostiest yet, Smithy maintaining an attitude towards his assistant of unprecedented silent and dour reproach. The silence became so oppressive, indeed, that even Dick's silver-steel nerves began to feel the strain.

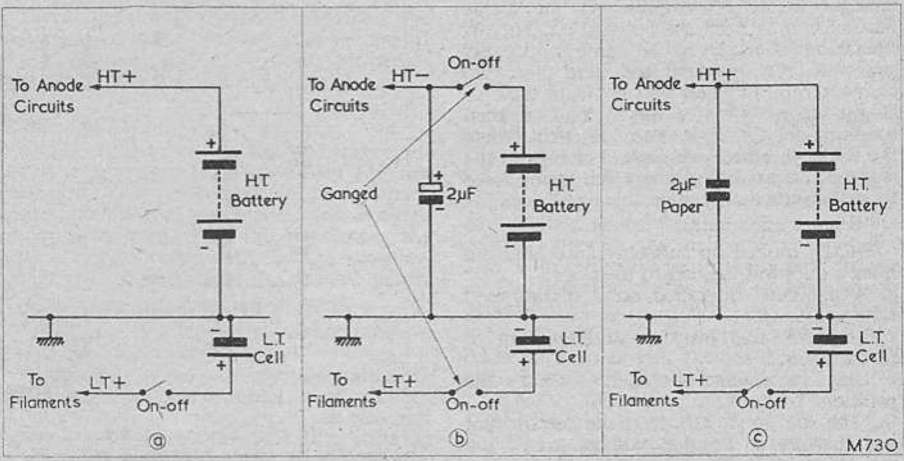


Fig. 4 (*a*) *In battery portables, especially the older models, it is usual to rely on a low internal resistance in the h.t. battery to prevent feedback between the stages.* (*b*) *Adding a condenser, as shown here, obviates the necessity of relying on a low impedance in the h.t. battery. If an electrolytic component is used, the h.t. battery must be switched out of circuit when the set is switched off to prevent discharge.* (*c*) *Providing it has a reliably high leakage resistance, a paper condenser can be used in place of the electrolytic component without the necessity of h.t. battery switching*

"Do you know of any other additions which may improve set performance?" he offered tentatively, his voice competing against the noise from the deluge outside.

"Well," said Smithy grumpily. "There's an oldie which might be worth while passing on. Quite a number of battery portables, including especially the older types, have no condensers decoupling their h.t. lines to chassis (Fig. 4 (*a*)). They rely instead on the h.t. battery maintaining a low internal impedance. Such sets can almost always be improved by connecting a condenser of some 2μF or more across the h.t. supply (Fig. (*b*)). This obviates the instance where the internal impedance of the battery rises sufficiently high for the set to become unstable whilst the battery still has plenty of volts left in it. The extra condenser across the h.t. supply gives extended battery life."

"What sort of a condenser would you suggest?"

"An electrolytic would be best, provided it's in good condition and has a low leakage current. And you must, of course, arrange for it to be disconnected from the h.t. battery when the set is switched off, or it will quickly discharge the battery. In some sets, the on-off switch only operates the l.t. supply, so you have to change this to a double-pole type in order to control the h.t. supply as well."

"If you used a paper condenser, couldn't you pop it permanently across the h.t. supply and save modifying the on-off switch?" (Fig. 4 (*c*).)

"On the assumption that its leakage resistance would be very high?"

"That's right."

"I suppose you *could* use a permanently connected paper condenser," conceded Smithy, "but you should check that its leakage resistance really *is* good and high."

"How would you check for leakage resistance?"

"One simple way consists of charging it up and seeing if you get as fat a spark out of it some time later as you do immediately after it has been charged. Thus, if a 2μF condenser held a full charge for, say, half an hour, you could say that its insulation resistance must be at least $1{,}000\text{M}\Omega$."

"How on earth do you arrive at that?" queried Dick, puzzled.

"Because the time constant given by 2μF and 1,000MΩ is 2,000 seconds; and 2,000 seconds is approximately equal to half an hour! Had the voltage across the condenser dropped to 37% of its initial value after 2,000 seconds, the leakage would have been exactly 1,000MΩ.

"Well, that's a neat dodge," said Dick. "You let the condenser test itself!"

"You do, indeed," confirmed Smithy. "And that's the end of technical nattering for today. What's the weather like now?"

As Smithy spoke, the clatter on the windows changed to a furious fusillade.

"I think," remarked Dick, mildly, raising his voice, "it's started to hail now."

MISCELLANEOUS

light MODULATION

by G5UJ

An interesting experiment was carried out recently by a friend of the writer. Briefly, it took the form of "light" modulation. The equipment needed (as a glance at Fig. 1 will show) is quite simple. A carbon, or similar microphone, is fed into a small two- or three-watt audio amplifier—which might well consist of an ordinary "domestic" receiver—the output being taken through a standard speaker transformer. The 3Ω secondary of this transformer has connected across it a 6.3 volt "spotlight" bulb, together with a 6 volt battery. The metal reflectors are removed from two electric hand torches and placed some distance apart, facing each other. The optimum distance between the two reflectors must be found by experiment, but 20 to 30 feet was quite satisfactory in this instance.

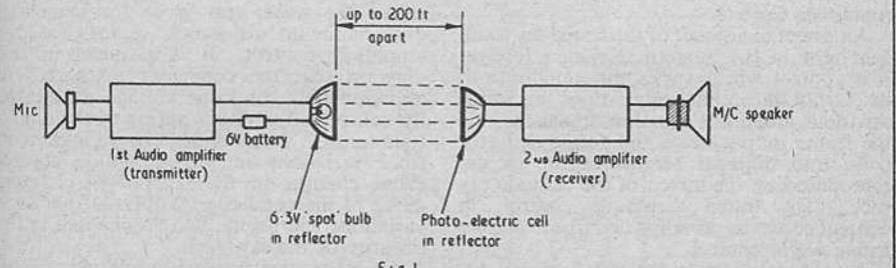


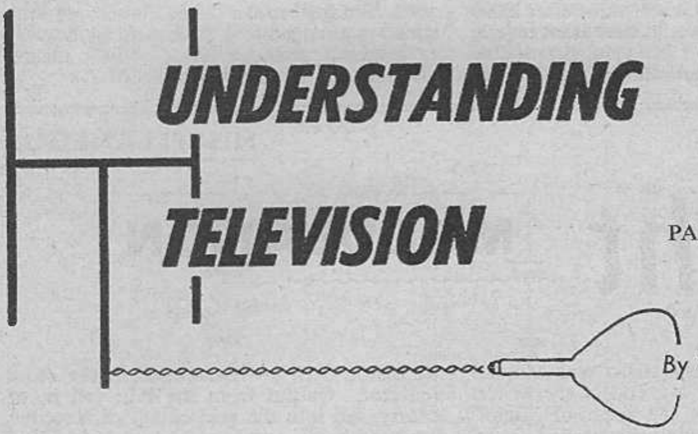
Fig.1
Light modulation system

As will be noted from the diagram at Fig. 1, the 6.3 volt bulb is mounted in one reflector connected in the output of the first, or "Transmitter" Amplifier, whilst a photo-electric cell—almost any type, or a phototransistor OCP71—is mounted in the other reflector. Output from the P.E. cell is, of course, fed into the grid circuit of a second or "Receiver" Amplifier, output then being taken in the normal way through a moving coil speaker.

Quite good speech quality was obtained even at distances up to 200 feet, but great care is necessary in placing the two "reflectors" in exact alignment.

It may also be desirable to try several different spotlight bulbs, as not *all* bulbs will be found suitable. Car head and sidelamp bulbs will not be found suitable as a rule, due to "time lag" in the filament when following fluctuations of speech, etc. In passing, it should be stressed that *direct* light from ordinary domestic a.c. mains lamps must not be allowed to impinge on the P.E. cell, or a.c. modulation will result!

Though perhaps not an original idea, the foregoing does seem to offer a wide scope for further experiment.



UNDERSTANDING TELEVISION

PART 25

By **W. G. MORLEY**

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

In last month's article we completed our discussion on sawtooth generators by describing the two basic types of multivibrators: the symmetric multivibrator and the cathode-coupled multivibrator. We saw also how the multivibrator might be synchronised, and how it may be made to produce a sawtooth waveform. We shall now briefly examine the circuits employed for sawtooth amplitude control, after which we shall carry on to the frame output stage.

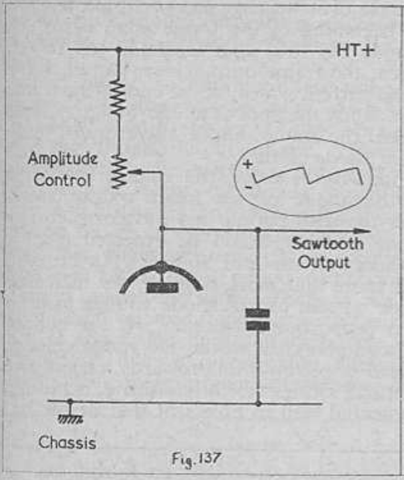
Amplitude Control

An essential adjunct of the frame sawtooth generator in the modern television receiver is a control which varies the amplitude of its sawtooth output. Variations in frame sawtooth amplitude are then translated, via the frame output stage and frame deflector coils, into different heights of the picture reproduced on the screen of the cathode ray tube. The frame amplitude control, in consequence, is usually described as the *frame height* control.

Amplitude controls are not provided for the line sawtooth generators in most modern receivers. This is because it is simpler to control the amount of horizontal deflection provided by the line deflector coils by fitting variable components in the line output stage itself. The line sawtooth generator then provides an output of fixed amplitude.

Fig. 137 illustrates a typical amplitude control. A variable resistor, in series with a fixed resistor to restrict its range, varies the resistance which appears between the h.t. positive rail and the condenser across which the sawtooth appears. When the full resistance of the control is inserted into circuit the voltage across the condenser rises less during the scan period of the cycle than it does when minimum resistance is inserted into circuit. In consequence, a control of sawtooth amplitude is obtained. Fig. 138 shows the waveforms given for maximum and minimum resistance settings of the amplitude control. It is assumed in this diagram that the condenser discharges to approximately the same voltage during the flyback period at either setting of the amplitude control. It has to be borne in mind that, since variations in the amplitude control cause changes in the exponential charging curve of the condenser, it follows that such variations will result, also, in changes in the linearity of the sawtooth.

An alternative type of amplitude control for frame circuits is shown in Fig. 139. In this diagram the amplitude control functions in the same manner as does an a.f. volume control, the series fixed resistor being included to restrict its range. This type of control is not often encountered in present-day receivers.



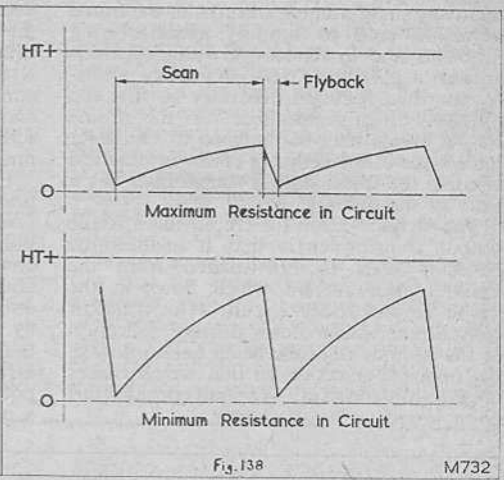


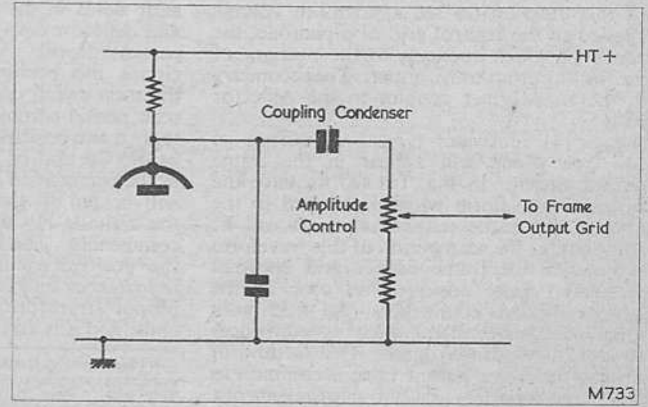
Fig. 137. *A sawtooth amplitude control. The condenser in this diagram is that across which the sawtooth is formed. Fig*. 138. *The action of the amplitude control of Fig*. 137. *The upper waveform shows the result of inserting maximum amplitude control resistance in circuit, and the lower waveform the result of minimum amplitude control resistance. It should be noted that, since more of the condenser exponential charging curve appears in the scan period of the lower waveform, its linearity is slightly worse than that of the upper waveform*

The Frame Output Stage

The function of the frame output stage is to feed a sawtooth current of adequate amplitude to the frame deflector coils. In conventional circuits this is achieved by the amplification of a sawtooth voltage applied to the grid of the *frame output valve*. In modern receivers, the frame output valve always feeds the frame deflector coils via a step-down *frame output transformer*. The frame output valve has to provide a certain amount of power and it is usual, in British receivers, to employ a valve of the type associated with sound output stages. Most American receivers employ valves of similar power-handling capabilities, although there has been a tendency in the past to use triodes of the 6SN7 class.

There are two main reasons for employing a transformer between the frame output valve and the frame deflector coils. One of these is due to the desirability of employing a

Fig. 139. *An amplitude control which has been employed in frame circuits in the past. The amplitude control functions in the same manner as an audio volume control*



relatively small number of turns in the frame deflection coils to simplify manufacturing problems and to reduce the voltages which appear across them. A step-down transformer then becomes necessary so that the relatively high impedance at the frame output anode may be matched to the lower impedance of the deflector coils. In practical circuits, the frame output transformer has a ratio of the order of 10:1.

The second reason for employing a frame output transformer is that it enables the deflector coils to be isolated from the unidirectional current which flows in the frame output anode circuit. The deflector coil current which causes upward deflection of the cathode ray tube beam has to flow in the opposite direction to that which causes downward deflection. We shall consider this point in greater detail shortly.

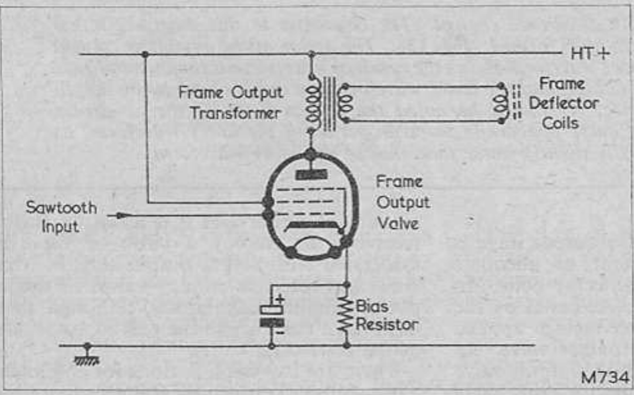


Fig. 140. *A basic frame output stage without linearising circuits*

A basic frame output stage, without linearising circuits, is illustrated in Fig. 140. In this diagram we see a sawtooth voltage applied to the control grid of a pentode, the anode of which connects to the primary of the frame output transformer. The secondary of the transformer couples to the deflector coils.

Fig. 141 illustrates typical waveforms of the type which will appear in the frame output circuit. In Fig. 141 (*a*) we have the sawtooth waveform which is applied to the grid of the frame output valve. It will be seen that, as the scan period of this waveform progresses, the frame output grid becomes more and more positive. As soon as the flyback period commences the grid goes quickly negative, after which it commences to go slowly positive again. This method of driving the frame output valve is common to all conventional circuit arrangements. Because of it we have the condition that, at the beginning of the frame scan, when the cathode ray tube spot is at the top of the screen, the frame output valve draws a low anode current whilst, at the end of the frame scan, when the spot is at the bottom of the screen, the frame output valve draws maximum anode current.

Fig. 141 (*b*) shows the voltage waveform on the anode of the frame output valve. Over the scan period this waveform corresponds to what would be expected from a consideration of grid voltage. As the grid goes more and more positive, the increased anode current causes anode voltage to drop by a proportional amount. At the end of the scan period, however, the anode voltage, instead of merely rising towards h.t. positive potential, swings violently positive, achieving a potential well in excess of that of the h.t. positive rail. This positive excursion is caused by the sudden collapse of the magnetic fields in the frame output transformer and deflector coils which occurs when anode current drops.[1] With a correctly designed circuit the positive excursion is of short duration and it ceases before the next frame scan period commences. It should be noted that, if the positive excursion does not cease before the end of the frame blanking period in the transmitted signal, picture information will be fed to the modulating electrode of the cathode ray tube before the frame scan commences. The length of time occupied by the positive excursion is governed by the inductances and self-capacities in the frame output transformer and frame deflector coils, and it is an important feature of design

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[1] This effect is the same as occurred in the blocking oscillator transformer discussed in "Understanding Television," Part 23 (December 1959 issue).

to ensure that these are not so excessive as to cause the positive excursion to last too long.

Fig. 141 (*c*) shows the voltage appearing across the frame deflector coils. As is to be expected, this is similar to that appearing on the frame output anode. There is, nevertheless, one important difference. As we observed earlier, the current which flows in the transformer primary during the scan period travels in one direction all the time, the only difference between the beginning and end of the scan period being one of current magnitude only. There is no d.c. connection between the primary and secondary of the frame output transformer, with the result that it is only the alternating component of the primary waveform which appears in the secondary circuit. As is shown in Fig. 141 (*c*), the voltage across the deflector coils changes polarity during the scan and is, at an instant near the centre of the scan period, zero. It follows from this that the current flowing through the frame deflector coils will similarly change direction as the frame scan progresses, and will also be zero at an instant near the centre. This state of affairs then allows the deflector coil current which deflects the beam upward at the start of the scan period to flow in the opposite direction to that which deflects the beam downward at the end of the scan period. At an instant near the centre of the scan there is zero frame deflecting current, and the electron beam travels straight through the frame deflector coils, suffering no deflection whatever.

When we considered a.c. couplings[2] we saw that an alternating waveform has an average voltage, this being equal to the sum of all the voltages which occur in a complete cycle. This average voltage is indicated in Fig. 141 (*c*). It should be noted that the pulse which occurs during the flyback periods prevents the average voltage line from passing through the waveform at the exact centre of the scan section. However, the time occupied by the flyback pulse is, relatively, a small fraction of that taken up by the complete

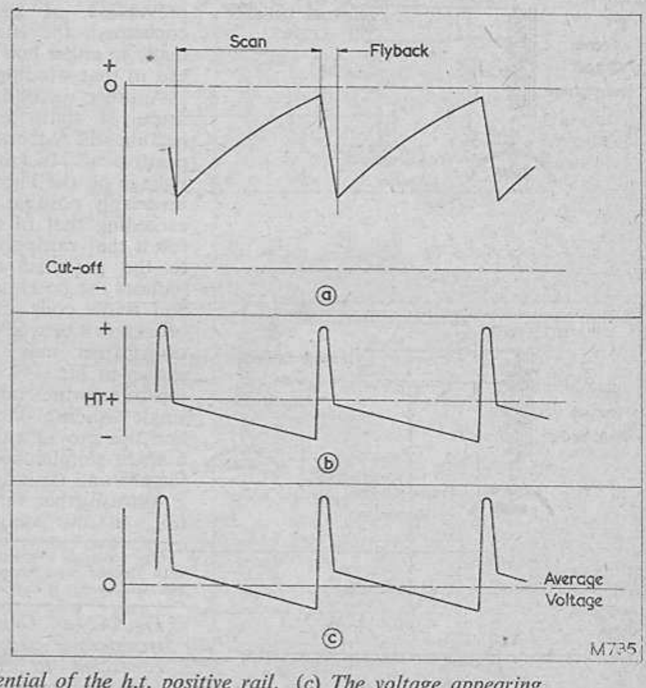

Fig. 141 (a). An example of the sawtooth voltage applied to the grid of the frame output valve. It will be seen that the grid goes progressively positive as the scan period proceeds. At no time does the waveform rise above cathode potential (whereupon grid current would flow) or fall below cut-off potential. (b). The waveform on the frame output anode. During the scan period the anode voltage drops, as would be expected from the increasingly positive grid voltage. During the flyback period, however, the collapse of the fields in the frame output transformer and deflector coils causes the anode voltage to rise well above the potential of the h.t. positive rail. (c) The voltage appearing across the frame output deflector coils, showing the position taken up by the average voltage line

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[2] "Understanding Television"—Part 21 (October 1959 issue).

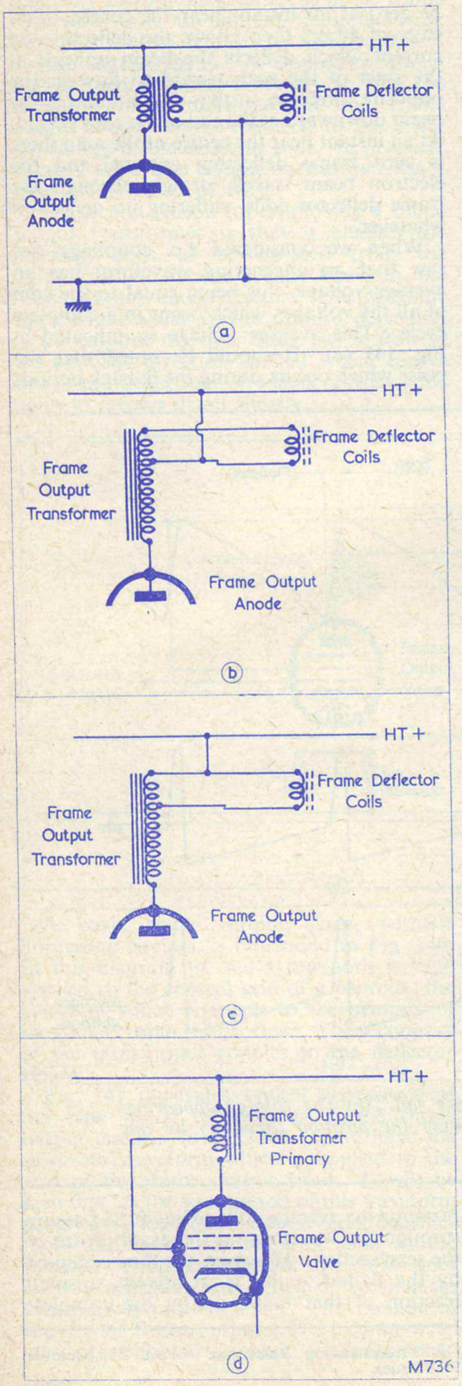

Fig. 142 (*a*). *One side of the frame output transformer secondary circuit may be connected to chassis to prevent the formation of high static voltages.* (*b*). *An alternative method of preventing static voltage build-up consists of connecting the secondary to the h.t. positive rail. In this case the frame output transformer circuit may be drawn as illustrated here.* (*c*). *In some receivers, the frame output transformer is an auto-transformer, the secondary being part of the primary.* (*d*). *In this circuit arrangement the screen-grid of the frame output valve is connected to a tap in the primary winding*

cycle, and it causes only a slight displacement of the average voltage line.

Frame Output Transformers

It would be helpful as this stage to quickly consider the various types of frame output transformer which are employed in modern receivers.

In Fig. 142 (*a*) we see, once more, the simple transformer which was used in Fig. 140. If the secondary of the frame output transformer were left unconnected to any other part of the receiver circuit, as it is in Fig. 140, it would be free to pick up static voltages which could be so high as to cause insulation breakdowns. (Under this condition the secondary circuit could be described as "floating."). In Fig. 142 (*a*) this problem is overcome by connecting one side of the secondary to the chassis. So far as the prevention of static voltage pick-up is concerned, the chassis connection may be made to either end of the secondary, or to a tap in that winding.

Another method of preventing the formation of static voltages consists of connecting the secondary circuit to the h.t. positive rail. In a modern receiver the average voltage on the line deflection coils is almost invariably positive of chassis by a potential exceeding that of the h.t. supply, with the result that raising the frame deflection coils to the potential of the h.t. positive rail reduces the potential difference between line and frame coils and, therefore, the risk of breakdown between them. The frame output transformer may then take up the form shown in Fig. 142 (*b*). It will be noted that the transformer now becomes, effectively, a single winding into which a tap is made,[3] and this provides the further advantage that a slight simplification in transformer manufacture and design results.

Yet a further variant is shown in Fig. 142 (*c*). In this diagram the frame output

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[3] In practice, the secondary section will be wound with thicker wire than the primary, because of the heavier current it carries.

transformer becomes an auto-transformer, because the secondary winding is also part of the primary. This arrangement offers the advantage of giving slightly tighter coupling between the primary and secondary than is given by Figs. 142 (*a*) and (*b*). There is also a small saving in wire and winding space in the transformer, since the secondary winding replaces an equal number of primary turns. It will be noted that this arrangement does not allow the d.c. isolation effect between primary and secondary referred to earlier to take place. In practice, however, the anode current flowing through the secondary coil is much lower than that induced in it, and the instant in the scan period at which zero deflection current flows is only partially displaced from its near-central position.

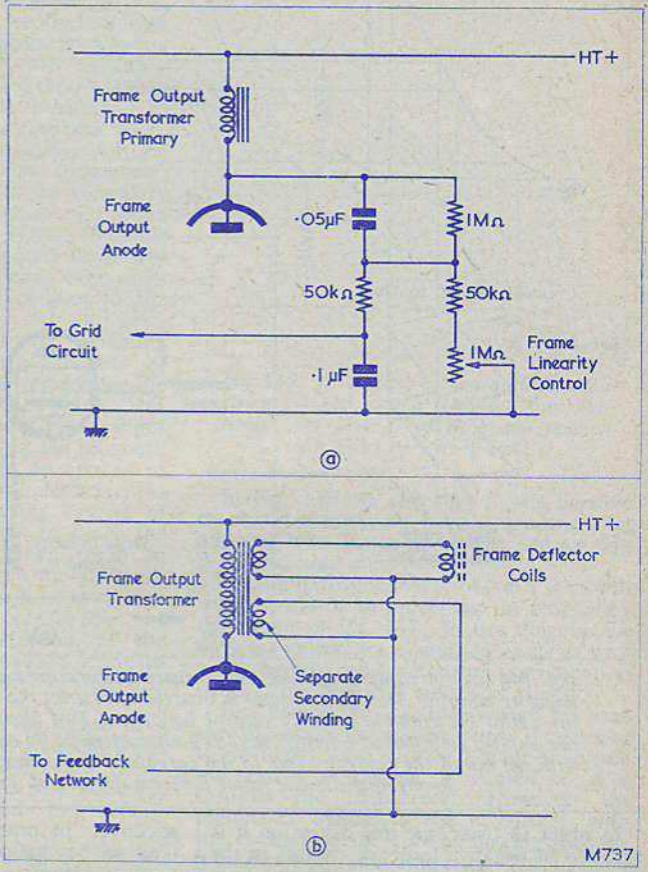

Fig. 143. *Due to the very wide variance in feedback frame linearity circuits employed in different manufacturers' receivers, it is difficult to generalise on this particular part of the frame output stage. Nevertheless, two fairly representative arrangements are shown here*

An elegant method of coupling the frame output valve to the frame output transformer which is encountered in some British receivers is illustrated in Fig. 142 (*d*). As will be noted, the screen-grid of the frame output valve couples to a tap in the primary winding. This method of connection is similar to the "ultra-linear" output circuit employed in high-quality a.f. amplifiers, and it helps to reduce overall distortion.

Frame Linearity

Whilst it is normally desirable to ensure that the sawtooth waveform applied to the grid of the frame output valve is reasonably linear, it will inevitably suffer some distortion in the frame output stage itself before it is applied to the deflector coils. Such distortion will be due to the fact that the I_aV_g characteristic curve[4] of the frame output valve is not

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[4] The curve given when anode current is plotted against grid voltage, anode voltage remaining constant.

entirely linear, and to the fact that distortion will be introduced by the frame output transformer.[5]

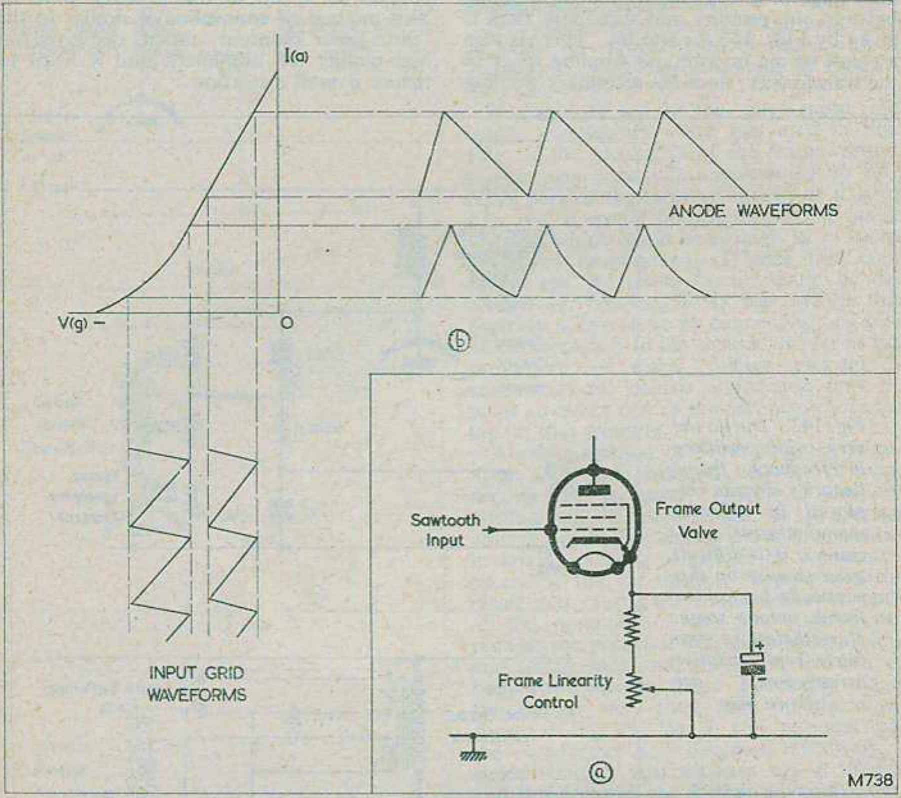

Fig. 144 (*a*). *A variable cathode bias resistor is sometimes employed as a frame linearity control. The fixed resistor is inserted to restrict the range of the control.* (*b*). *How the cathode linearity control functions. Two identical grid waveforms are applied to different parts of the IaVg characteristic by adjusting cathode bias with the aid of the control. Due to the curvature of the characteristic, the waveforms at the anode suffer different degrees of distortion*

In order to overcome this distortion it is usual to fit negative feedback circuits in the frame output stage, these including at least one variable resistor so that a control of the amount of feedback applied becomes available. The feedback circuits employed differ considerably from those found in a.f. amplifiers because the frame output stage normally has little excess gain "in hand." In consequence, frame output feedback circuits tend to be designed such that they improve linearity over part of the scan only, this being achieved by the use of resistor and condenser networks which are frequency-selective. In practice the feedback circuits tend to be "tailor-made" to fit the frame output circuits developed by individual manufacturers and, due to a very wide variance from make to make, are rather difficult to divide into basic categories. Some fairly typical basic circuits are, nevertheless, given in Fig. 143. Fig. 143 (*a*) shows a circuit arrangement wherein negative feedback is applied from the anode of the frame output valve back to its grid. A control of the amount of feedback obtained is provided by the variable resistor. The values given in the circuit are fairly representative. The 0.1μF condenser presents a low reactance to the swiftly-changing flyback

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[5] The latter will be caused by the fact that coupling between primary and secondary cannot be made perfect, and because the permeability of its iron laminations will vary as the current flowing through the primary changes.

pulse, and a relatively high reactance to the slow-changing scan section of the anode waveform. In consequence, the feedback loop provides much heavier attenuation of the flyback pulse than of the scan period. Since the variable resistor of Fig. 143 (*a*) controls the amount of negative feedback provided, this component is described as the *linearity control*.

An alternative approach is shown in Fig. 143 (*b*). In this circuit the feedback voltage is obtained from a special secondary winding on the frame output transformer. Using a separate secondary winding has the advantage of causing the frame output transformer to be partially included in the feedback loop, thereby assisting in compensating for the distortion introduced by this component. Feedback loops connected to the secondary which feeds the deflector coils are not found very frequently, because the voltage available is usually too low. The separate secondary winding of Fig. 143 (*b*) will have more turns than the secondary which couples to the deflector coils.

An alternative method of obtaining variable control of linearity consists of providing a variable cathode resistor for the frame output valve, as in Fig. 144 (*a*). This changes the cathode bias of the frame output valve, and, in so doing, causes the sawtooth on the frame output grid to be applied to different parts of the I_aV_g characteristic. See Fig. 144 (*b*). The varying degrees of curvature in the characteristic to which the grid waveform is applied then result in varying degrees of linearity in the sawtooth waveform at the anode. Speaking in general terms, this type of linearity control does not function by correcting distortion, as the feedback circuits do. Instead, it tends to compensate for distortion[6] by offering opposing distortion.

Control of frame linearity by means of a variable cathode resistor was frequent some years ago in British receivers, but is rarely used in current models. It is still, however, fairly extensively employed in modern American receivers.

Some receivers employ two frame linearity controls. Of these one is normally of the anode-to-grid feedback type, and provides the greater degree of control. The second may then merely cause small alterations to be made to the frequency response of the overall loop, whereupon it affects only a small part of the picture. Alternatively, the second linearity control may consist of a variable cathode resistor.

Since linearity controls tend to vary the gain of the frame output stage, adjustments in linearity almost always incur compensatory adjustment of the frame height control.

Inductive "Sawtooth-Forming Circuit"

Before carrying on to the next subject, the line output stage, we should now briefly consider a type of "sawtooth-forming circuit" which forms the basis of this stage. This is the inductive "sawtooth-forming circuit."

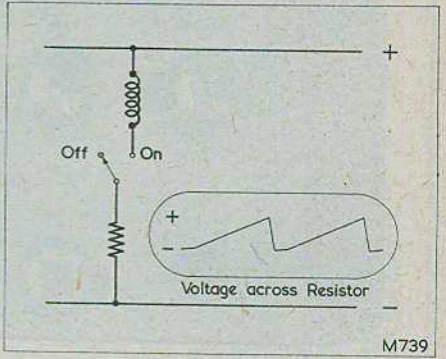

Fig. 145. An inductive "sawtooth-forming circuit." The switch is closed for relatively long periods of time and opened for short periods of time

In Fig. 123[7] we saw that it was possible to obtain a sawtooth from a condenser by allowing it to charge up slowly, and causing it to discharge quickly.

It is similarly possible to obtain a sawtooth with the aid of an inductance by employing the circuit of Fig. 145. In this diagram we have an inductance connected in series with a switch and a resistor, the series combination being connected to a source of supply.

Just before the switch is closed we have the case where the voltage across the resistor is, obviously, zero. At the instant of closing the switch, a current is caused to flow through the inductance. However, the inductance opposes a rise in current; with the result that the current flowing through it increases at a slow rate only. This increase in current causes a continuously increasing voltage to be dropped across the resistor. If we open the switch again the voltage drops to zero. By keeping the switch closed for a relatively long period and open for a relatively short period, a sawtooth becomes available across the resistor. This sawtooth is illustrated in the diagram.

Next Month

In next month's article we shall carry on to the line output stage.

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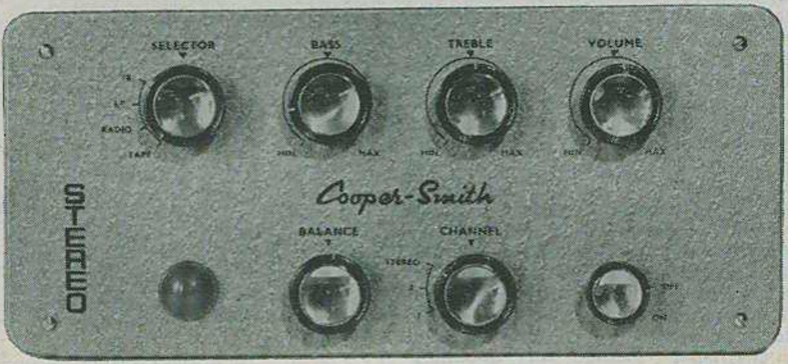
[6] Including non-linearity of the sawtooth voltage applied to the grid.

[7] "Understanding Television," Part 22 (November, 1959, issue).

The Cooper-Smith Stereo Control Unit



Part Three, *conclusion*

Stage Four

Up to now the wiring has been identical for both channels. In this final stage the balance control and channel selector switch are wired up; and, as will be seen from the theoretical diagram, the two channels differ.

Fit S_2, S_3, VR_2 (500kΩ) and the panel lamp holder (see Fig. 8). (In this drawing the valveholders are not shown, the wires going to them terminating in their approximate position.)

S_2 (2)—S_2 (4)—S_2 (6)—VR_5 (1) (rear section)
S_2 (3)—S_2 (7)—S_2 (8)—VR_5 (1) (front section)
TS (4)—P_1 (orange/white/yellow)—V_2 (7) Chan. 2*
TS (6)—P_2 (brown/grey/yellow)—V_2 (7) Chan. 2*
VR_2 (1)—V_2 (7) Chan. 1
VR_2 (2)—TS (6) Chan. 1
VR_2 (3)—TS (10) Chan. 1
Panel light tags to V_1 (4 & 5)
Output cables—S_2 (1) (Chan 2) and S_2 (5) (Chan 1). Join screening of each together and solder to frame of S_2 (see Fig. 9).

Power cable:
Twisted flex to both of TS (1) (heater leads)
Orange lead to TS (14) (h.t.+) (screening of output cable is h.t.−)
Two white leads to S_3 (mains switch leads)
Connect up plugs according to socket connections on main amplifier.

N.B.—Before fitting plugs to the leads, slip the two rubber grommets over them, one on the power cable and one on the two output cables.

Setting Up

Fit the front of the case over the control bushes, fit the seven spare nuts and tighten with a spanner. The panel may now be attached to it and the knobs fitted and lined up in their appropriate positions. It is not necessary at this point to fit the cover, but if this is not done a considerable amount of hum will be experienced.

Fit the valves into their appropriate sockets.

Plug the coaxial output leads into the input sockets of the main amplifier (or amplifiers). In the case of the "Twin Six" Stereo main amplifier the lead from Channel 1 should be marked in some way and taken to the socket marked "R". If using two Model B.P.I. amplifiers Channel 1 will go to

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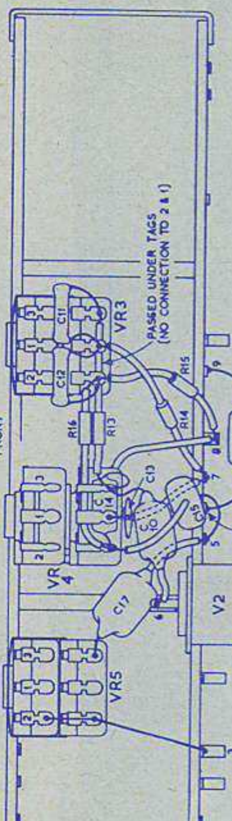
* In the theoretical diagram the fixed potential divider P_1/P_2 is shown in Chan. 1 and the Balance Control in Chan. 2. It is, however, more convenient to reverse them in the actual building, and does not affect the operation.

whichever amplifier is feeding the right-hand speaker.

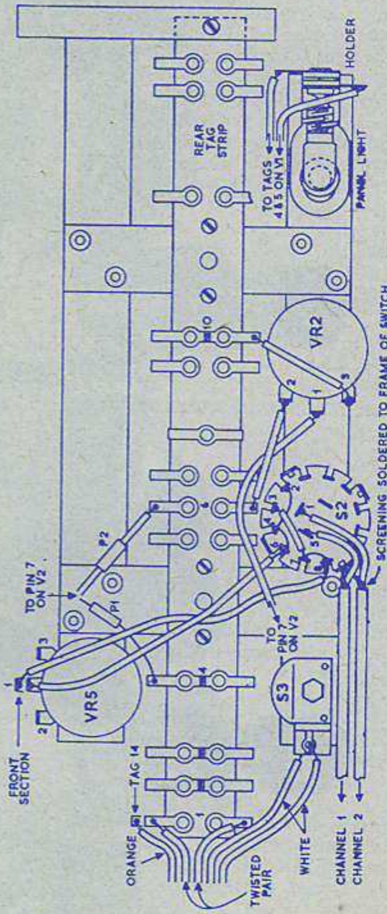
Connect the loudspeakers to the appropriate output sockets and plug in the power supply cable. Do not connect mains yet.



TOP VIEW OF WIRING (CHAN.2) AFTER FITTING POTENTIOMETERS
(REPEATED ON OTHER SIDE (CHAN 1) USING FRONT SECTION OF POT'S)

Fig. 7

STAGE THREE



COMPLETION OF WIRING, VIEWED FROM REAR
(VALVE HOLDERS NOT SHOWN FOR CLARITY)

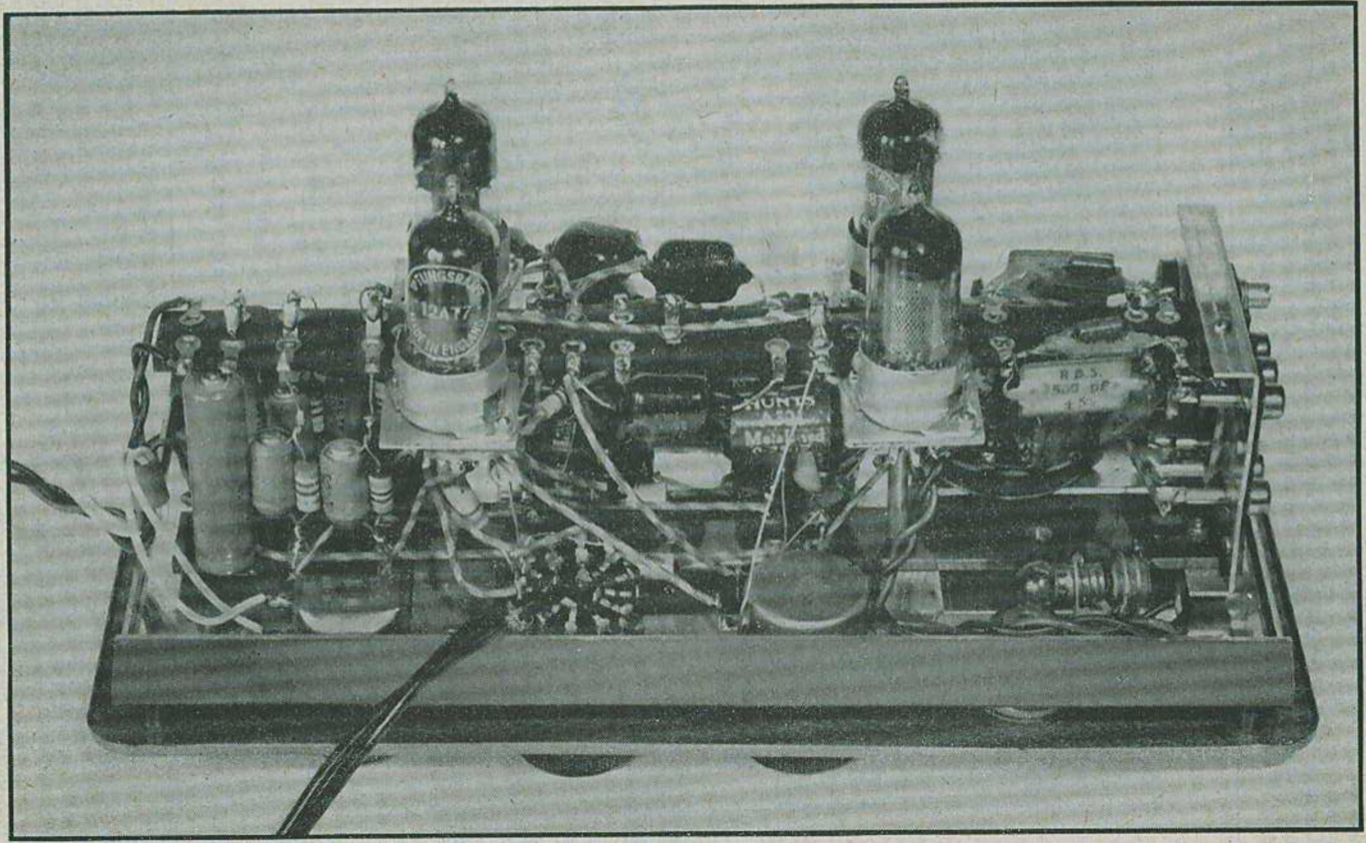
Fig. 8

STAGE FOUR

Turn input potentiometers (VR$_1$) fully clockwise and plug stereo pick-up leads into "Gram." input sockets, following manufacturer's instructions as to "left" and "right" channels. Set selector switch to "L.P." and channel switch to "1". Turn balance control about two-thirds clockwise and tone controls to mid-setting, mains switch "off" and volume control to maximum.

Connect mains and switch on. Check that valve filaments are glowing, and if all is well, after about ten seconds a hum should be heard from the speakers. Reduce volume control to about half-way.

Select a *monaural* record (long-playing; a 78 r.p.m. record must *never* be played with a stereo pick-up), preferably one of a small group or a soloist, and play it without touching any control other than the volume. If you are using a crystal pick-up it is likely that considerable distortion will be present;



Rear-of-panel view of the Cooper-Smith Stereo Control Unit this is because the pick-up is overloading the input, and the input potentiometer controlling Channel 1 should be adjusted until the distortion disappears and the main volume control begins to overload the amplifier at about three-quarters rotation. Switch to Channel 2 and adjust its input control until the volume sounds equal to that of Channel 1.

Sit midway between the loudspeakers at a distance of about six feet. Facing these the sound should appear to come from a point somewhere in front of you and not from the speakers; if this is not so the speakers are wrongly phased and the connections to *one* of them must be reversed.

Switch to "Stereo" and ascertain that the balance control affects the right-hand speaker. If this is not so, change over the speaker plugs on the main amplifier(s) and recheck for "phasing" as above.

Now comes the time for you to enjoy the benefits of your new equipment to the full. Put a stereo record on the turntable. If this is of a symphony orchestra the violin section should appear to come from the left and the lower strings from the right; if the orchestra appears the wrong way round simply reverse the pick-up input plugs. Soloists should appear dead centre; this may be achieved by adjustment of the balance control. One of the many stereo test records now available will be of great value to you in setting up your equipment as regards speaker placing, phasing, balance, etc.

Radio. Although you may not yet be able to use your equipment for stereo radio, a considerable improvement over single channel set-ups will be obtainable by using both loudspeakers. When a "monaural" source (radio *or* pick-up) is reproduced in this way the increase in realism is immediately apparent; the "hole in a box" effect is eliminated and the sound appears to emanate, not from the speakers themselves but from space somewhere between them and covering a larger area.

All you have to do is to plug a radio tuner (preferably f.m.) into one channel of the control unit and turn the channel selector switch to that channel. This automatically puts the main amplifier channels in parallel so that both loudspeakers are being fed with the same signal. As only one channel of the control unit is in use, if the switch is left on "Stereo" only one channel of the main amplifier, and consequently only one speaker, is in use; if turned to the other channel no sound will, of course, be heard.

Playing 78 *r.p.m. Records*. The last condition mentioned above may be used in the following manner. If your pick-up is not of the "turnover" variety (much better not!) a separate pick-up will be required for 78s. This should be of the high quality crystal type with an output of around 100mV or less and could be plugged into the unused "Radio" socket.

A word of warning! Although your stereo pick-up may be used to play monaural *L.P.* records, as stated previously it must *never* be used to play 78s. It would take only one playing to turn the stylus point into a lethal weapon as far as stereo records are concerned! A 78 stylus, of course, already is!

Tape. The input sensitivity of the control unit is not sufficiently high to work straight from a tape head; it is intended to work from one of the many excellent tape units now available which incorporate an equalising pre-amplifier and have an output in the region of 100mV. The more experienced constructor may prefer to build his own pre-amplifier, which should preferably be self-powered but may possibly, with care, be powered from the existing equipment.

Fitting into a Cabinet

Cut out an aperture 10¼in x 4½in and insert the unit. With this held in position the cover can be slid on (the two grommets on the output cables engaging in the slots on the right) and the two finger nuts fitted, no other fixing being required.

Adapting two B.P.I. Amplifiers for Use with the Stereo Control Unit

1. From *one* of the amplifiers remove R_{18} and replace with a 10kΩ 1 watt resistor. Call this No. 1 amplifier.

2. If not already fitted, a two-pin socket should now be inserted, in the hole provided, in the chassis of the same amplifier. (This socket is normally used for the gram. motor mains supply.) Connect one tag of socket to 1 on fuseholder and the other to 1 on mains selector.

3. To a length of twin lighting flex (about 18in) solder a plug to fit the above socket and on the other end a mains plug to fit the amplifier mains socket.

4. Short out pins 4 and 5 on power socket of amplifier No. 2. Now when the above link is plugged into the two-pin socket of amplifier No. 1 and the mains socket of amplifier No. 2, the on-off switch on the control unit will affect both amplifiers simultaneously.

5. Power supply for a tuner unit is taken from amplifier No. 2. Control unit power supply cable is connected to an octal plug, wired the same as a Mk. II control unit except that there is no connection to pin 3 (earth), and plugged into amplifier No. 1.

Warning

The earth return for the stereo control unit is formed by the screening braiding of the coaxial output cables, and if the coaxial plugs are pulled out without first switching off a nasty shock may result.

RADIO — Topics

By Commentator

Code Practice

We came across an interesting idea in the correspondence columns of a yachting magazine recently. The writer suggested that his readers wishing to polish up their morse speed might do so by using a tape recorder, recording the code slowly from, say, a buzzer and then playing it back faster. This is no doubt obvious enough, but what did catch our eye was his statement that using a recorder with a ten watt amplifier, he could feed the output into a flash lamp bulb which, even at half volume, would light brilliantly from the code tones on the tape. In this way, he brushed up his speed for flashed code signals as well as audio ones! Ingenious!

Battery Tape Recorders

The progress which has been made in battery tape recorders in recent years is quite phenomenal. It does not seem long ago that letters from readers asking for designs and constructional articles on this type of equipment were a frequent occurrence in one's mailbag, most of them asking for such information because there was nothing of the sort available commercially. Apart from the novelty of such instruments, one would not have thought that there was much call for them, but presumably the rapid advance in their design has been stimulated by a brisk demand and good sales. They are now available at prices varying from around the £25 mark up to £60 or so. Such refinements as governed motor speed, controlled by a transistorised electrical centrifugal governor, are available in even the moderately priced models. From a perusal of magazine advertisements, it seems that it is the amateur cine enthusiasts who represent the best market for this type of equipment. Thanks to magnetic strip and various quite satisfactory mechanical synchronisation equipment, sound recording on one's own films appears to be on the increase. Having recorded the natural sounds for the scene filmed out in the field, so to speak, it is subsequently transferred to the permanent sound record in the edited version of the film. It is certainly an easier way of going about things than trying to set up one's own home sound effects department!

Kinderdorf, Childrens' Villages

From *Monitor*, the official journal of the International Short Wave League, we hear of a praiseworthy project in Austria, in which two radio amateurs play a large part. At Imst in the Austrian Tyrol, the "S.O.S. Children's Village Society" was started in 1949 by Hermann Gmeiner. Its aim was to try and restore the atmosphere of family life to children who had become separated from their parents. By 1957 they had succeeded to the extent of having found permanent homes for no less than 162 children in 18 houses. The idea has spread to other villages, and in one, Hans Steinkeller, OE7JN, is caretaker of the village and has his shack in its grounds. He is assisted by Haymo Leitner, OE7LN. Many radio amateurs in Austria have a great interest in these Childrens' Villages and special QSL cards are printed with the purpose of making the villages better known. Moreover, an award is issued to both transmitting and SWL enthusiasts, the fees for entering for the award being used to help these villages. Further particulars can be had from S.O.S. Kinderdorf, Imst, Austria.

In the same strain, we see from "QST" that, on Christmas Day, 52 children in the National Foundation Hospital for Asthmatic Children in Tucson were enabled to talk to their parents by means of amateur radio. The originator of this scheme is W7CKV, and last Christmas was the third occasion on which this treat for these children and their parents had been arranged.

Smaller and Smaller

When the technique of introducing radio active substances into the body, so that their passage through the various systems could be traced, was developed, it seemed that the ultimate in discovering what goes on in the hidden depths of the body had been reached. But not so. Now we read that miniature radio transmitters have been developed at the National Institute for Medical Research which can be swallowed, sending out as they pass through the digestive system information on such matters as acidity, stomach pressure, temperature and so on. The radio signals are picked up on a suitable receiver located in the same room as the patient. The size of these "super miniatures" is given as about a third of an inch in diameter and two-thirds of an inch long. Some research work has been done in the past on the effects of exercise, for instance, on the human body in which the changing factors were recorded on the active participant himself and radioed back to the laboratory via a small v.h.f. transmitter carried on his back, but this new midget is certainly "going places."

British Interplanetary Society

On the face of it, the British Interplanetary Society might appear to offer little of interest to the radio enthusiast. But radio, being the connecting link between satellites and the earth, figures very largely in all interplanetary considerations. The Society publishes two periodicals: its *Journal*, which is highly technical, dealing as it does with the intricacies of astronautics; and *Spaceflight* which is intended for the more general reader. The latter magazine is full of matter for those interested in guidance systems, radio control and kindred subjects. Further details of membership, etc., can be had from the Secretary, B.I.S., 12 Bessborough Gardens, London, S.W.1.

Amateur Stereophonic Transmissions

From the Australian journal *Amateur Radio* we learn that an Australian radio amateur, VK3AXU, has successfully transmitted stereophonic sound. As he moved about his shack, the effect was well reproduced at the receiving station. VK3AXU wonders if he is the first radio amateur in the world to carry out experiments of this sort.

Electronic Explosive Gas Detection

That electronics can be applied to just about everything goes without saying, these days. From a brochure issued by IEC-SIEGER Ltd. we learn how electronic gas detectors work. Apparently there are two basic methods of inflammable gas detection. One employs catalytic principles, the other relies on osmosis of the gas through a porous pot—thus producing a pressure change.

The catalytic reaction of platinum and palladium to an inflammable gas is well known. Gas lighters use a platinum filament which is heated by an electric battery. Surface combustion of the gas occurs on the warmed platinum wire which raises the filament to incandescence, thus igniting the gas. This process is ultised in gas detectors. A filament is heated electrically and, if inflammable gas is present in its vicinity, it becomes further heated—when its change of resistance can be ascertained electronically and used to actuate a variety of warning devices.

In those working on the osmosis principle, a pressure change produced by diffusion of the gas through a porous pot causes a diaphragm to close electric contacts and thus operate an alarm.

Both types have their snags. The filaments in the catalyst type may become so hot that they burn out. Some gases produce the opposite pressure change to others, so that if set for one series of gases they will not work with others. These difficulties have been overcome in the IEC-SIEGER Electronic gas detectors, which use several catalysts impregnated on to insulating material, heated by wire coils in a balanced electronic circuit. Attention to other details of this nature has produced a design which aims at removing most of the difficulties encountered with equipment of this type.

Frequencies for Space Research

According to reports in the daily press, the ITU Conference in Geneva has allocated certain radio frequencies for satellite and radio astronomy work. Considerable radio interference has occurred on frequencies used for this purpose, as readers who have tried to listen to the various sputniks will know. We have read reports of interference with the work of various radio telescopes from nearby t.v. stations, car ignition and so on, so it seems very appropriate that such frequency allocations should be made. Satellites and radio telescopes are expensive enough to warrant special precautions to ensure that the information obtained is accurately conveyed back to earth.

Electronic Morse Code Keys

Amateur radio CW enthusiasts have, so far, had to peruse the advertisements in the American amateur radio journals and sigh "I wish they sold them over here," as they looked longingly at the glossy pictures of those American electronic "bug" keys.

Now, however, they can buy an English version and, from the writer's experience with one of them, they will not be disappointed with their purchase. Electronic Devices (Cheltenham) Ltd., Wellington Rd., Cheltenham, market a range of such keys, details of which those interested are well advised to obtain.

TEST EQUIPMENT

A SENSITIVE A.C. Millivoltmeter

by **A. BARTLETT STILL**

Performance

Voltage measurement range, 5mV to 30V r.m.s.

Frequency response (±½dB/1 kc/s), 15 c/s to 150 kc/s.

Input impedance, 10 Megohms

Output impedance, 1,000 ohms.

Maximum output voltage, 30V r.m.s

Maximum unweighted noise (equivalent input), 150µV.

"A BAD WORKMAN WILL ALWAYS BLAME his tools." That is an old adage that may very well be true, but it is also true that a craftsman cannot produce his best with poor tools; an inaccurate rule would mean inaccurate work.

In the broad field of Electronics, whether professional or amateur, the "rule" is replaced by the "meter," but the principle still holds. Without a meter, guesswork holds sway; with one of only doubtful accuracy, the position may be even worse. "Guesstimation" can be remarkably near the truth at times, but when it contradicts a measurement, confidence in that measurement is essential.

As a result, it has long been the writer's assertion that "test gear," to be of any use at all, should be beyond reproach in the manner in which it carries out the task for which it is designed. With this frame of mind established, it is obvious that a most careful choice will be exercised when purchasing commercially-built equipment, particularly as cost is a very real factor often cutting right across any other aims.

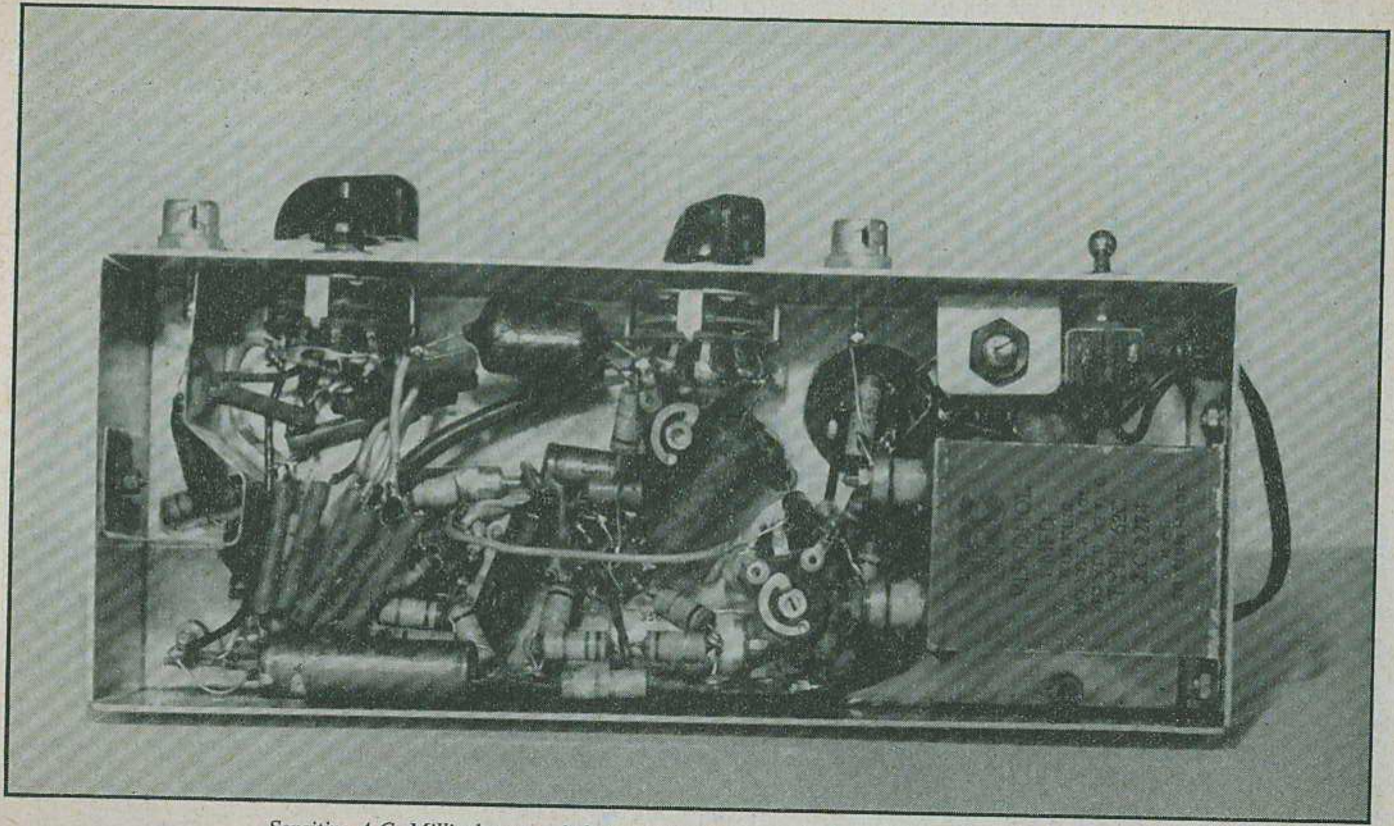
It often happens that the equipment needed is not available commercially or, if measuring up to the standard set above, is far too costly. Under such circumstances the alternatives are a continuance of the guesswork or a bit of "Do-it-yourself," a phrase whose meaning, it is suggested, was known to amateur radio enthusiasts long before it achieved popular appeal.

The writer has for a long time been keen on all aspects of magnetic sound recording and found himself in the unenviable position described above with respect to the measurement of low level a.c. signals. It was not expected that an a.c. millivoltmeter which would be sufficiently versatile and flexible to warrant the making, and reliable enough to encourage confidence, could be constructed entirely from the junk box, but in the end the cost of special components was kept to a remarkably low level. The unit to be described has been in regular use for over a year and has earned its rightful place on the test bench.

In spite of the fact that the unit had to be designed to be largely self-calibrating, when an occasion arose to make comparison with a well-known and respected commercial instrument no fault could be found.

The original specification called for an a.c. voltmeter capable of accurate measurement from 10mV to 10V over a frequency range covering the lowest audio signal (25 c/s) to the highest bias oscillator frequency (100 kc/s). In order to cause little or no change to the circuit under test, a high input impedance and low capacity were obvious requirements. Four basic units were therefore necessary:

A cathode follower input.
An accurate step attenuator.
A stable amplifier of high gain.
An accurate a.c. voltmeter of adequate frequency range.



Sensitive A.C. Millivoltmeter—below-chassis arrangement of amplifier section of instrument

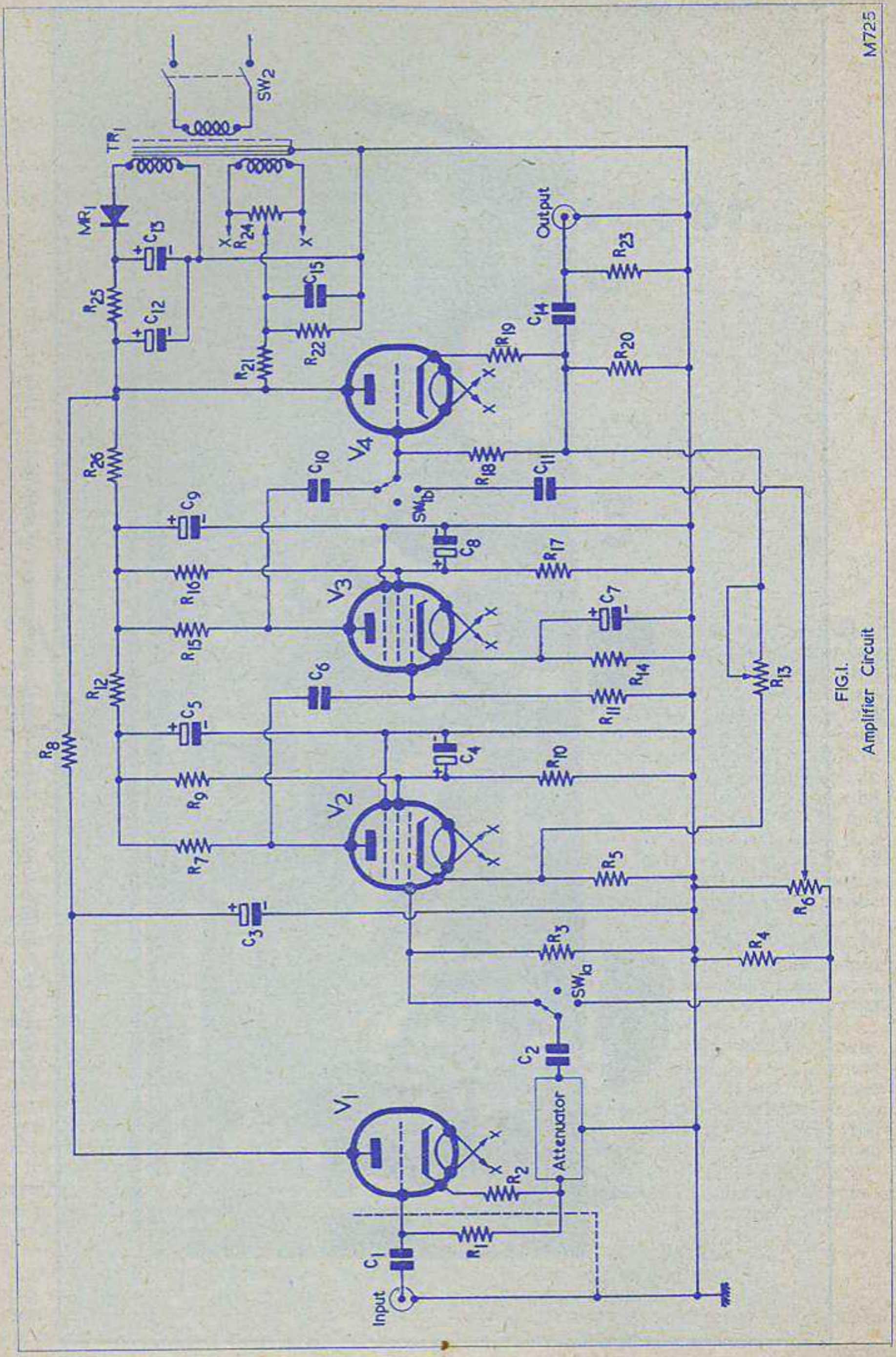


FIG.1.
Amplifier Circuit

As will be seen from the photograph, it was decided to keep the actual voltmeter as a separate unit, thus providing for separate use a calibrated amplifier and increasing flexibility. For this reason, mainly, a cathode follower output stage was added to widen the range of load impedances to which the amplifier might be connected. A further refinement was the addition of a switch allowing the amplifier to be bypassed in order that the attenuator only (together with the input and output stages) might be available.

It was at first anticipated that a stabilised power supply for the amplifier would be desirable, but experiment soon showed that with the amount of negative feedback in use (some 30dB) this was unnecessary. In fact, half-wave rectification only has been used, and with the one mains tap for 230V no measurable change in amplifier gain occurred, over the whole frequency range, when the mains input was varied from 150V to 270V. Below 150V the short term stability was good, but the gain tended to drop as the valve heaters cooled!

The circuit diagram of the amplifier is shown in Fig. 1, and it will be noticed that the attenuator has been indicated by a block diagram, being drawn out separately in Fig. 2. This not only simplifies the amplifier circuit, but also draws attention to the fact that the attenuator is, in reality, the most important part of the whole equipment, since it is on this unit that the calibration accuracy depends.

Deferring consideration of the attenuator for the moment therefore, it will be seen that the amplifier itself is reasonably straightforward. The input cathode follower is conventional, and in order to increase its voltage handling capabilities the h.t. is taken directly from the smoothed supply. In view of the high impedance of this stage, and the order of gain involved, it was found necessary

COMPONENTS LIST

Arranged for easy reference to Fig. 1

AMPLIFIER

Resistors (½W, 10%, unless otherwise stated)

R_1	1MΩ*
R_2	4.7kΩ
R_3	200kΩ 5%*
R_4	200kΩ 5%*
R_5	820Ω*
R_6	See text
R_7	200kΩ*
R_8	15kΩ
R_9	200kΩ*
R_{10}	100kΩ*
R_{11}	200kΩ*
R_{12}	47kΩ
R_{13}	See text
R_{14}	2.2kΩ
R_{15}	200kΩ
R_{16}	200kΩ
R_{17}	100kΩ
R_{18}	100kΩ
R_{19}	1.5kΩ
R_{20}	22kΩ
R_{21}	560kΩ
R_{22}	250kΩ
R_{23}	1MΩ
R_{24}	100Ω w/w pot'r
R_{25}	2.2kΩ 1W
R_{26}	22kΩ

**indicates high stability*

Capacitors (350V wkg, unless otherwise stated)

C_1	0.01μF 500V
C_2	0.25μF
C_3	8μF (elect.)
C_4	2μF (elect.)
C_5	4μF (elect.)
C_6	0.1μF
C_7	25μF 12V (elect.)
C_8	2μF (elect.)
C_9	16μF (elect.)
C_{10}	0.05μF
C_{11}	0.05μF
C_{12}	32μF (elect.)
C_{13}	32μF (elect.)
C_{14}	1μF (paper)
C_{15}	0.1μF

Miscellaneous

V_1	Osram L77
V_2	Osram Z729
V_3	Osram Z729
V_4	Osram L77
SW_1	Switch, rotary 2-pole 3-way
SW_2	Switch 2-pole mains
MR_1	Rectifier, contact-cooled, 250V 20mA
TR_1	Mains transformer, pri. 230V; secs. h.t. 200V 20mA, heater 6.3V 1A

ATTENUATOR

Resistors (all ¼W 1% high stability)

AR_1	200kΩ
AR_2	100kΩ
AR_3	150kΩ
AR_4	100kΩ
AR_5	150kΩ
AR_6	100kΩ
AR_7	150kΩ
AR_8	100kΩ
AR_9	150kΩ
AR_{10}	100kΩ
AR_{11}	150kΩ
AR_{12}	100kΩ
SW_3	Single-pole, 6-way wafer switch

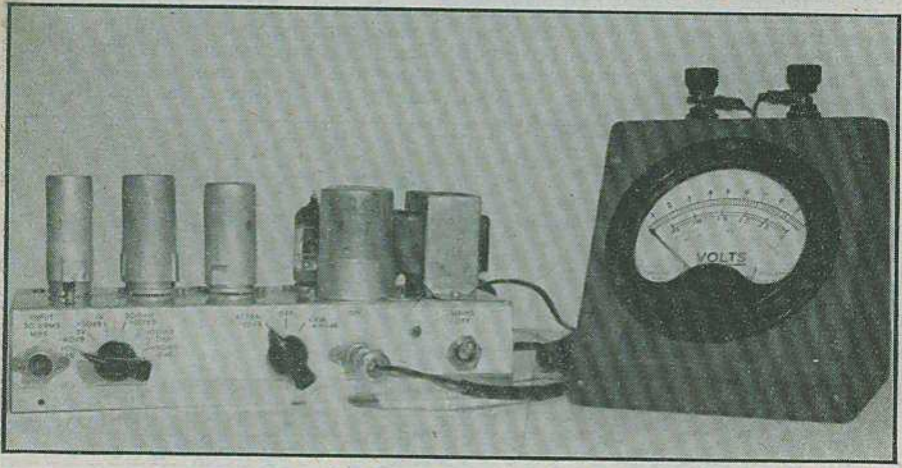
to decouple between the anodes of the input and output cathode follower valves. The attenuator represents a cathode load of 68kΩ. The value of grid resistor of the first pentode amplifier is important as it represents the load seen by the attenuator and simulates an infinite number of further steps.

The design of the two stages of pentode amplification is conventional, though in the interests of gain stability the screens are fed from a potential divider. The second valve again has a fairly low value of grid resistor in order to reduce the high frequency loss due to such "Miller Effect" as does exist. As a result a reasonably large value of coupling condenser is required.

The output cathode follower stage is again straightforward, negative feedback being taken from the cathode load to the cathode of the first amplifier. A variable feedback resistor is used in order that the amplifier gain may be adjusted on calibration. A d.c. connection is used here; the resistance is sufficiently high in view of the voltages involved, and undesirable frequency effects are thus avoided. The input and output of the amplifier stages incorporate switching. The attenuator must again be terminated with 200kΩ, and a preset gain control is fitted. The two cathode follower stages must introduce some loss, and this control is therefore adjusted to make the total loss up to 10dB.

One final point in respect of the amplifier —the biggest single source of noise was found to be heater/cathode pick-up on the input valve, whose cathode is some 60V above chassis. In consequence a humdinger is fitted, with the centre-tap taken to a d.c. level that is a few volts higher.

As a study of the underside chassis photo will reveal, construction was carried out with a view to keeping all connections short and direct. The attenuator resistors look particularly untidy, largely due to their being spaced out in order to reduce capacity shunting. A ladder attenuator is used, having the twin advantages of presenting a constant cathode load to the valve, and utilising two values of resistor only. As has been said earlier, the accuracy of the whole instrument depends on the attenuator and for this reason 1% tolerance components are specified. The resistors used in the writer's unit, and shown in the photo, are "Labgear", but it is suggested that Erie type 109 be used. This is purely because the Erie type, though fatter, are somewhat shorter and may be wired more conveniently round the switch.



The complete instrument, showing separate m.c. indicator

The voltmeter itself may be as good as the constructor can affard. The writer's was made up from a 100μA moving-coil movement. Four germanium diodes are used as a bridge rectifier and high stability carbon resistors for the series "K". These were adjusted so that the meter read 10V a.c. full-scale on a 50 c/s supply. (It turned out that the basic 100kΩ needed to be shunted by 1MΩ.) Two points arise with respect to the meter: crystal diodes must be used if the frequency response is to be satisfactory, and 10V is the minimum scaling that is advisable; too much non-linearity is introduced at lower values.

It was found a great temptation to increase the sensitivity of the meter, apply a little less feedback to the amplifier, and, as a result, have a maximum sensitivity of 10mV f.s.d. This was successfully resisted, and it is believed that the accuracy and stability that have been proved are ample compensation.

Constructional Notes

The general arrangement of the writer's instrument is fairly clear from the photographs, and represents, it is believed, as compact a unit as should be attempted. The same circuit has been built up as a rack-mounted unit with more generous chassis layout and was equally successful.

A screen, isolating the input circuitry in its own separate compartment, is strongly recommended; the high input impedance would otherwise give trouble with hum pick-up.

The values of the various electrolytic capacitors used are not critical. They may certainly be larger, and it is quite likely that some reduction in value could be tolerated. Under these circumstances it would be advisable to check the low frequency performance.

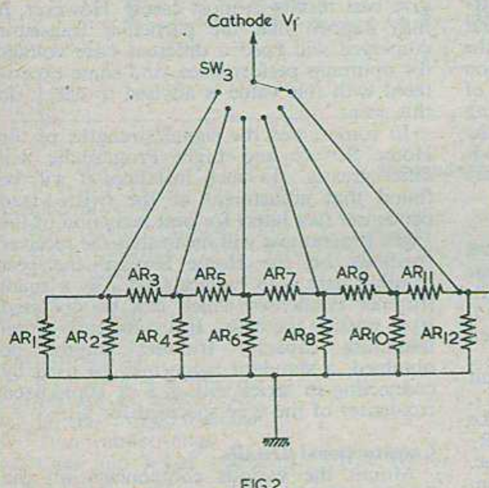


FIG.2.
Attenuator Circuit

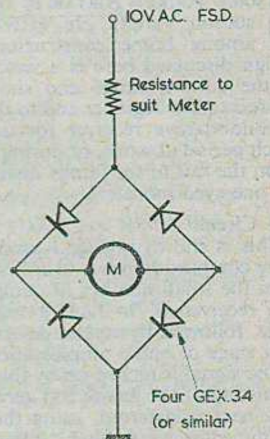


FIG.3.
Meter Circuit.

The h.t. rectifier used was contact cooled, rated at 250V 20mA, and is tucked down in one corner of the chassis. In addition to this supply, 6.3V at 1A for the valve heaters is required from the mains transformer.

In view of the fact that test gear may be used with a variety of other equipment, it is imperative that the transformer is a double-wound one. The type of small transformer used on self-powered Band III converters is often suitable, but the extra loading of a pilot lamp might be too much.

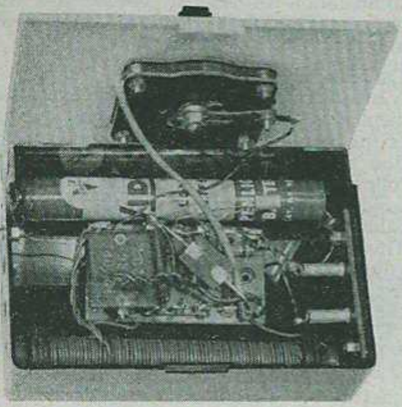
The two pre-set variable resistors are shown in the circuit diagram as 1MΩ. In the interests of long-term stability these should be used for a rough calibration only, a combination of smaller pre-set and fixed resistor (Hi-Stab if possible) being finally inserted.

Calibration

In order to calibrate the complete instrument it is necessary only to adjust the gain of the amplifier, and the additional attenuation required to bring that of the cathode followers to 10dB. A transformer heater winding will provide a suitable signal for calibration, but 10V a.c. is rather better. This may be checked on any ordinary a.c. voltmeter that is available or may be borrowed for the occasion. The first step is to check the instrument meter and adjust the series "K" if necessary.

Switching to "Amplify", with the attenuator all in, the preset is then adjusted so that insertion of the complete amplifier between the test signal and the meter results in the same reading (i.e. the correct one). This assumes a correctly adjusted meter, and will result in an amplifier gain of exactly 50dB. Calibration can be effected by comparing the complete instrument with the borrowed voltmeter, when any inaccuracy in the meter is compensated. The second preset is adjusted with the instrument switched to "Attenuate" and the attenuator all out. In this instance a loss of 10dB is looked for.

The Attenuator/Amplifier thus has a total range of −60 to +50dB.



The "SUPER" TRANSISTOR CRYSTAL RECEIVER

Described by E. GOVIER

SMALL POCKET PORTABLES OF THE LOCAL-station variety are extremely popular among home constructor circles; the design discussed here is a welcome addition to the current range and should prove of interest to the beginner and to those requiring an unobtrusive receiver for use during the lunch period at work, or during those periods when the rest of the family insist on watching the one-eyed monster!

The Circuit

This is shown in Fig. 1, and is somewhat more complex than would at first sight appear from the small number of components used. The receiver is, in fact, a regenerative r.f. stage, followed by crystal detection and then by a stage of audio amplification!

The signal is picked up by the tuned circuit consisting of the ferrite rod aerial L_1 and C_1. It is next transferred, using the winding L_2 for impedance matching, to the base of TR_1—here acting as a regenerative r.f. stage. Regeneration is obtained by feedback from the collector of TR_1 via the condensers C_3, C_4, to the base via windings L_1, L_2, and the condenser C_2.

At r.f. the earpiece winding acts as a choke, and the amplified signal is passed via C_5 by choke-capacity coupling to the voltage doubler detector formed by D_1 and D_2. The rectified output from the detector is now applied, by d.c. coupling, to the base of TR_1, which now operates as an audio amplifier. The collector load is again provided by the winding of the earpiece.

Notes

The value given for R_1 has been found to give best results in most cases. However, it may happen that the particular transistor employed will need a different base voltage for optimum performance, and some experiment with this value is advised to check on this point.

In some areas the signal strengths of the Home Service and Light Programme will differ greatly. In such instances it will be found that adjustment of the twisted-lead condenser (see later) for best reception of the Light Programme will mean that the receiver oscillates on the Home Service—the best solution here is to replace C_3–C_4 by a small trimmer condenser which can be operated from outside the case. If a sufficiently small minimum capacity trimmer cannot be obtained, a standard value may be used by connecting in series with a 5 or 10pF fixed condenser of the type specified for C_3.

Constructional Details

Mount the various components on the 7-way tagboard as shown in Fig. 2, by suitably shortening and "binding" the wire ends—do *not* solder them into position at this stage. Commence the foregoing by joining together tags 1 and 5 (see Fig. 3), with a short length of insulated wire. Similarly connect together tags 2, 4 and 6; following this by joining together tags 10, 11 and 12. Next, mount R_1 into position between tags 6 and 7 (see Fig. 2). Similarly, position (i.e. do not solder) C_5 between tags 3 and 10. Position the crystal diode D_1 between tags 4 and 11, at the same time ensuring that the *red* end connects with tag 11. Position the remaining diode D_2 between tags 5 and 12 (*red* end to tag 5). Connect approximately 2½ inches of p.v.c. wire to tag 3, leaving the other end of this wire free for the time being.

The White Spot transistor may now be soldered into position, taking the usual precautions with respect to heat damage. Solder the collector to tag 3, the base to tag 4 and the emitter to tag 5. Next, solder all the connections to tags 2, 6 and 10. Solder one end of C_3 to tag 3, and position only the remaining end to tag 14. Position one end of a 2in length of p.v.c. wire to tag 14, leaving the other end free. Position one end of a 2¼in length of p.v.c. wire to tag 12 and leave the remaining end free.

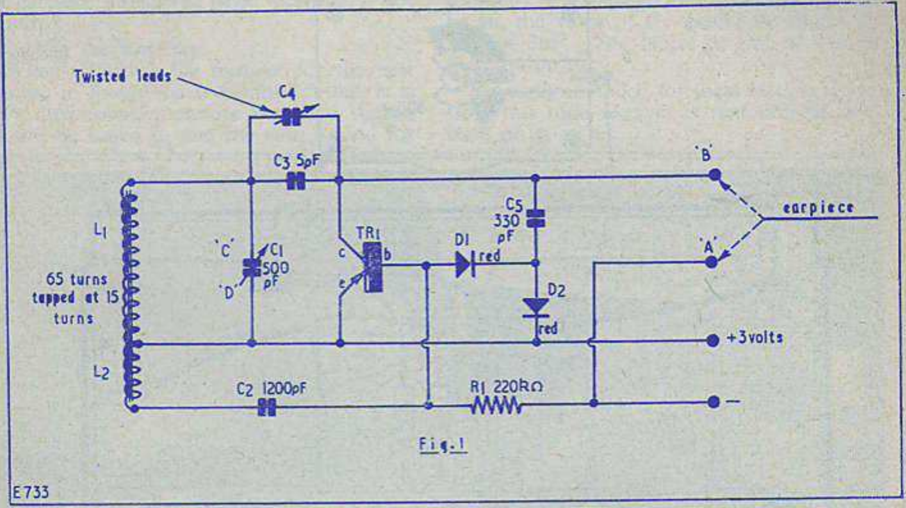


Fig. 1

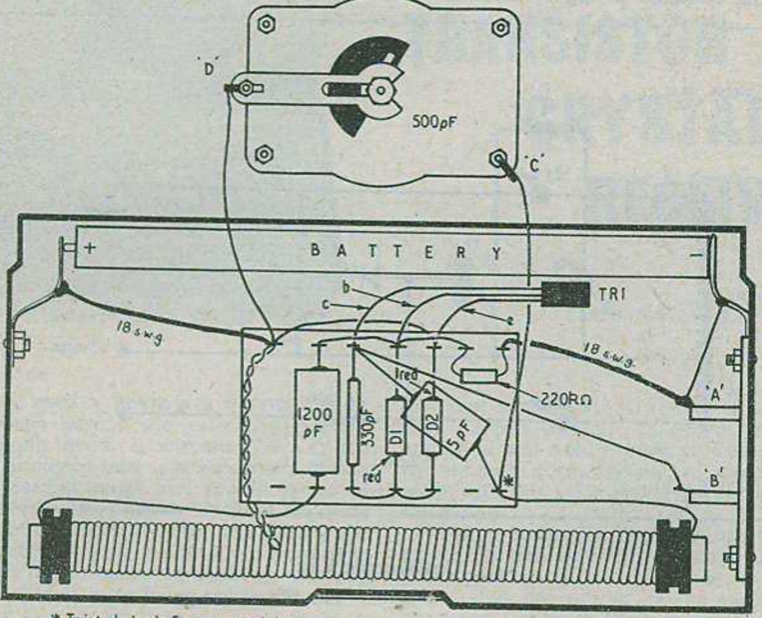
Components List

Capacitors
C_1 500pF variable
C_2 1,200pF
C_3 5pF
C_4 See text
C_5 330pF

Miscellaneous
R_1 220kΩ ⅛ watt
TR_1 R.F. White Spot
D_1, D_2 Crystal diodes
Two wander-plugs
Case and 7-way tagboard. Clyne Radio Ltd.
Double socket panel
4in Ferrite rod, Clyne Radio Ltd.
Two ⅜in rubber grommets
Two battery clips, Clyne Radio Ltd.
3 yds. 22 s.w.g. P.V.C. wire
6in 18 s.w.g. wire (tinned copper)
Pen-torch battery
Three 6BA ¼in screws and nuts, one 6BA washer
Magnetic deaf-aid type earpiece (alternatively, DLR5 headphone), Clyne Radio Ltd.

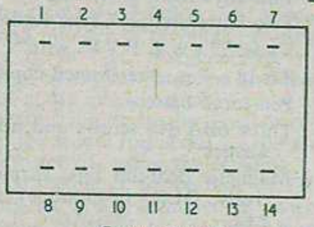
Dealing next with the ferrite rod aerial, first push one rubber grommet on each end of the rod material. Insert a small screwdriver blade between the rod and one grommet in order that about 3 inches of the 22 s.w.g. insulated wire may be inserted through the grommet. Remove the screwdriver blade, when it will be found that the grommet will hold the wire into position whilst winding operations commence. First, close-wind 15 turns, then twist a loop of approximately 1½in (3in of wire), twisting the wire tightly down to the 15th turn. Resume winding, ensuring that the turns are in the same direction as hitherto, and complete a further 50 turns, thus totalling 65 turns in all. Insert the screwdriver blade through the remaining rubber grommet and feed the wire end through, withdrawing the blade as soon as this is done. This latter operation is apt to be a little "tricky"—the designer insists that four hands would be useful here! Push the last-mentioned grommet tightly against the end of the winding in order to ensure that all turns are close-wound. Leave about 3in of free wire.

Mount the small brass battery clips to the side of the case by means of the screws and nuts provided, and also fit the paxolin wander-plug socket strip. (See Fig. 2.) Solder into position a small length of bare wire between socket "A" and the negative end battery clip. Position the tagboard within the case by means of a short length of 18 s.w.g. wire between wander-plug socket "A" and tag 7 of the tagboard.



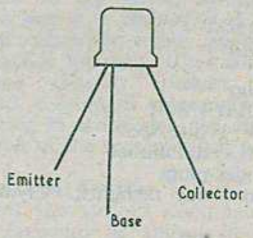
*Twisted leads C_4 connected here

Fig.2



7-way tag board

Fig.3



E734

Fix into position the tuning condenser C_1 on the lid of the case. Solder about 3in of insulated wire to both tags "C" and "D" of C_1. (See Fig. 2.)

Position the ferrite rod aerial in the case as shown, and bare about ¼in of insulation from the junction of L_1–L_2 (twisted lead) and position this on tag 1 Solder a short length of 18 s.w.g. wire to the positive battery clip. Position the lead from tag "D" of C_1, and the other end of the 18 s.w.g. wire from the positive battery clip, to tag 1. Solder all connections to tag 1.

Connect the start of the aerial winding to tag 9 and solder together all connections to this tag.

Join the end of the aerial winding left free, together with that wire from tag "C" of C_1, and position these to tag 14. Solder all connections to this latter tag.

Connect the loose lead from tag 3 to wander-plug socket "B" and solder these connections.

Twist the leads from tags 3 and 14 together, these forming the condenser C_4 of Fig. 1. The precise amount of "twist" required will be found later.

Fit the control knob to the spindle of C_1 and follow this by checking all connections both with reference to the circuit diagram and those shown in Fig. 2. Insert the battery, ensuring that the polarity is correct —see Fig. 2. Insert the earpiece into circuit; this forms the on-off switch—make sure that the earpiece is removed when reception is not required.

Adjusting the Receiver

When adjusting the receiver for the best results, it should be remembered that it is very directional, therefore the local station should be tuned in and the case turned for optimum audio response. The twisted leads forming the condenser C_4 of Fig. 1 control the amount of regeneration and these should be adjusted for the best possible performance. Once found, the untwisted wire should be cut off about an inch from the last twist. Should a particularly high gain transistor be used in the circuit, the regeneration may be found to be somewhat excessive. Should this be so, the value of C_3 should be altered to that of 3pF. (See Notes at end of Circuit Description.)

Primarily intended for local station reception, this little receiver is undoubtedly in a class of its own.

Our stand being prepared for the Radio Hobbies Exhibition. Dr. A. C. Gee, G2UK, Associate Editor and Hon. Secretary of the British Amateur Radio Teleprinter Group, is seen in the foreground. Talking to him is Mr. J. H. Burrows, Business Manager, and on the left is Mr. O. Rundle of the Accounts Dept.

MULLARD PREMIUM FOR THE TELEVISION SOCIETY

In order to encourage the presentation of original papers on various aspects of television, Mullard Ltd. are offering the Television Society a new yearly premium of £20.

This premium will be awarded by the Council of the Television Society to the author of the best paper submitted during the year and subsequently published in their journal.

MORGANITE RESISTORS LTD. SIEMENS EDISON SWAN LTD.

The above companies have announced that by mutual consent they are terminating existing arrangements on 31st December, 1959.

Continuity of supplies will be ensured by: The Radio Resistor Company Ltd., 50 Abbey Gardens, London, N.W.8, who will, as from 1st January, 1960, handle all sales to wholesalers and retailers of Morganite Resistors Ltd.'s products. *(see also foot of page 530)*

TRANSMITTING

Getting Started on RTTY

by Arthur C. Gee, G2UK

Hon. Sec., British Amateur Radio Teleprinter Group

Part 4

BEFORE WE GO ON TO FURTHER PRACTICAL considerations, it might be as well to devote part of this month's article to some theoretical aspects of FSK transmission. Next month, we will deal similarly with FSK reception. The B.A.R.T.G.'s exhibit at the Radio Hobbies Exhibition proved as interesting an experience for the author as it did for the many who took more than just a passing interest in it. Having been on the Stand most of the time and having talked with many of those who sought information on amateur radio T/P communications, he feels better able now to assess the type of information needed. It was surprising how few opponents of RTTY expressed their objections and how many radio amateurs seemed keen to try their hand at this new facet—as far as British radio amateurs are concerned—of the hobby of amateur radio transmission. It was exceptionally gratifying, too, to have been selected as one of the items included in the B.B.C. TV News coverage of the Show.

It seems that the FSK mode of radio transmission and reception is little understood by the average radio amateur. It will make the operation of the gear subsequently to be described more easy if the principles of this system are briefly outlined before we proceed to practical instructions on construction.

But before we do this, a word or two further on the question of power supplies for the T/P. We are most grateful to a reader, Mr. P. H. Priest, for some more information on this subject. He writes as follows:

"I have been following your articles on RTTY in *The Radio Constructor* with great interest, and I think I might be able to help you out with some of the equipment adjustment. . . . Older Type 3s have only a 110 volt motor, others have tappings for various voltages. The standard voltage now used is 160 volts. Rectifier No. 43A gives 110 volts only, for motor supply. Rectifier Type 60A gives a 160 volt supply, again for motor supply, and it will give enough current to supply several motors. Types 66A, 66B and 66C will supply 160 volts for the motor and an 80+80 volt signalling supply. Rectifiers Type 26, etc., supply 80+80 volts signalling voltage only, and must be used in conjunction with Rectifier 43A."

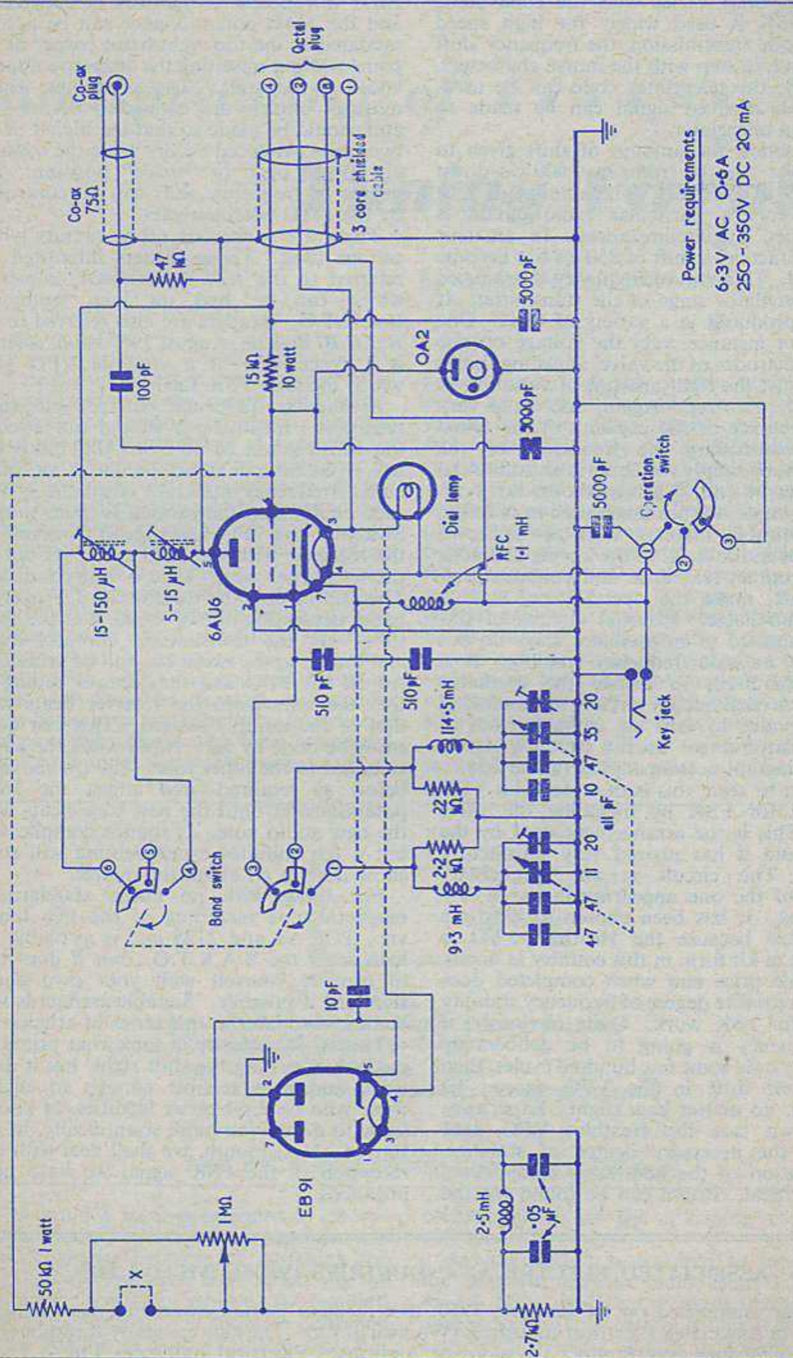
This is just the sort of information your contributor wants, to help make this feature as informative as possible. So many thanks, OM, for this.

* * *

To return to FSK; as we have already said in these articles, RTTY signals could be of the "on-off" type as used in normal CW practice. Apart from a number of disadvantages inherent in such a practice, the system known as FSK—frequency shift keying—gives many definite advantages for the radio operation of teleprinters. In this system a continuous signal is radiated, not an intermittent one. One obvious advantage of this is that, under conditions in which rapid fading is occurring, the receiver automatic volume control can operate continuously. With normal CW, an efficient a.v.c. may amplify the noise during the spaces between the code characters so that the noise and signal level merge. This does not happen with FSK as the signal is continuous—as in phone operation.

Again, an FSK transmitter is operated at constant load. This helps in the elimination of such troubles as key clicks, varying power supply current, and the host of similar troubles frequently found in amateur CW transmitters. It eases very considerably the problem of TVI.

The "intelligence" is conveyed on this continuous carrier by changing its frequency slightly—only a matter of cycles—so that the



HEATHKIT V.F.O - MODEL VF1U - MODIFICATIONS FOR F.SK frequency shift varies with the code being sent. FSK is used widely for high speed morse code transmission, the frequency shift then being in step with the morse characters. Similarly, the teleprinter code can be used, when the received signal can be made to operate a teleprinter.

In practice, the amount of shift given to the carrier may be from, say, 900 c/s down to 30 c/s or even less. The amount of shift used over any particular radio circuit is determined by circumstances. In amateur RTTY practice, a shift of 850 c/s has become standard. This shift of frequency is produced in the oscillator stage of the transmitter. It can be produced in a variety of ways. One could, for instance, vary the voltage on one of the electrodes of the valve, adjusting things so that just the right amount of variation in frequency occurred. Again, one could vary the inductance or the capacity of the tuned circuit controlling the frequency of the oscillator, by simply switching in an additional condenser or coil. Such methods, however, though simple, are not much used in practice, as undesirable features such as unknown capacities in the leads to the keying contacts, keying contact resistance and voltage variations, etc., make the operation of such a circuit unreliable. External circuits of this type connected to an oscillator stage do not make for reliable frequency stability. It is usual, therefore, to isolate the oscillator stage from such outside circuits by employing another valve to vary the characteristics of the oscillator stage. Such a circuit is shown in the diagram accompanying this article.

As can be seen, this is of a Heathkit VFO modified for FSK by including the valve EB91. This is the arrangement used by the author and it has proved very satisfactory indeed. The circuit is an "anglicised" version of the one appearing in the *RTTY Handbook*. It has been chosen to illustrate this article because the Heathkit VFO is available in kit form in this country at a very reasonable price and when completed does give the requisite degree of frequency stability needed for FSK work. Quite obviously, if the frequency is going to be deliberately shifted by only some few hundred cycles, then a constant drift in the VFO cannot be tolerated, no matter how slight. Experience has shown that the Heathkit VFO does provide the necessary degree of stability. The location of the additional components is not critical. Room can be found for the EB91 valveholder at the back of the chassis, and the 1MΩ potentiometer can be accommodated at the top right-hand corner of the panel without upsetting the attractive appearance of the unit. The teleprinter transmitting contacts are connected across "X" and should be made so that the higher of the two tones produced occurs when the contacts are in the open or "space" position. The degree of frequency shift can be controlled by the 1MΩ potentiometer.

There are numerous other circuits which can be used. Those readers interested are referred to the *RTTY Handbook*, copies of which can be had on loan from the B.A.R.T.G. Readers are also referred to the *R.S.G.B. Bulletin*, August 1957 issue, wherein is a description of a versatile VFO Unit which includes FSK facilities.

Setting the frequency shift presents some problems. Ideally, one should not attempt the construction of an FSK Unit until one has a calibrated audio oscillator or other audio frequency standard available. With such equipment, the process is quite simple. Switch on the VFO, and tune in the signal on the receiver, with the BFO on. Sort out on the teleprinter which tone is being radiated. This can be done by turning the T/P over by hand, depressing one of the keys at the same time. As the transmitting contacts make and break, so the two tones will be produced. Adjust the BFO and the receiver tuning so that the note from the receiver beats with that of the audio standard. This can quite easily be done by ear. Now switch the audio standard to the other tone—850 c/s above or below as required—and adjust the 1MΩ potentiometer until the new tone beats with the new audio note. It sounds complicated, but a few minutes experimenting will soon show how to go about the matter.

For those with no audio standard, a magnetic tape recording of the two tones, viz., 2975 c/s and 2125 c/s, is available on loan from the B.A.R.T.G.; but it does pay to provide yourself with your own audio standard if possible. Suitable standards will be described later in this series of articles.

This is, of necessity, a somewhat primitive method of getting the shift right, but it does work and it is reliable enough to enable those who have no better facilities, or knowledge to do the job more scientifically, to get started. Next month, we shall deal with the reception of the FSK signal we have now produced.

ASSOCIATED ELECTRICAL INDUSTRIES (WOOLWICH) LTD.

It was announced on 1st January, 1960, that Siemens Edison Swan Ltd. has changed its name to Associated Electrical Industries (Woolwich) Ltd. The new company is responsible for managing four new Product Divisions of Associated Electrical Industries Ltd.

Bandspreading of Tuning Circuits

By W. E. THOMPSON, A.M.I.P.R.E., G3MQT

A PROBLEM WHICH CAN CONFRONT THE constructor is the means, and sometimes the method, of opening out the scale of the tuning condenser of a receiver so that signals which are close to each other in terms of frequency can be adequately separated. This applies particularly at the higher frequencies when a waveband may occupy only a small part of the tuning scale, making station separation difficult. Short-wave listeners and licensed amateur transmitters are fairly well acquainted with the effects that poor bandspread can have on their reception conditions, and the newcomer to short-wave listening soon comes to appreciate that a receiver with good bandspread, and consequently better apparent selectivity, is desirable if not essential. Those who have attempted to improve upon a receiver's bandspread, or tried to build a receiver intended to incorporate as much bandspread as possible, will acknowledge the problem of assigning the best values of inductance and capacitance for the tuning circuits to achieve the required degree of bandspread. It must be conceded that the solving of such problems may not appear easy, but this article attempts to point to a way of calculating the required values by using fairly simple mathematics, and to explain some of the difficulties that can arise in dealing with a typical example.

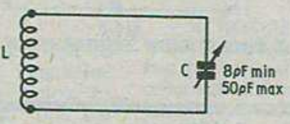


Fig.1
Basic circuit to tune 3·5 to 3·8Mc/s, with mid-point at 3·65Mc/s when C is at mid point of 29pF

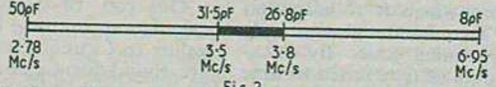


Fig.2
Showing small amount of bandspread achieved with the circuit of fig.1

E719

If a tuning circuit is to be designed to cover a specific range of frequencies, it is at once obvious that the range of frequencies over which the circuit will tune is related to the amount by which the capacity of the tuning condenser can be varied. It is, of course, axiomatic that the smaller the range of the tuning condenser the better will it spread out the range of frequencies over its scale, since the capacity-swing per degree of rotation is less with a small condenser than with a large one. However, using a small tuning condenser will not solve the problem entirely; other factors enter into the circuit considerations, as the following examples will show.

Assume that it is required to tune over the 80-metre amateur band, from 3.5 Mc/s to 3.8 Mc/s, and that a small tuning condenser is available having a maximum capacity of 50pF and a minimum capacity of the order of 8pF. The condenser therefore has a swing of $50-8\text{pF}=42\text{pF}$. Also, assume that the mid-point of the band, 3.65 Mc/s, is to be located at the mid-point of the condenser swing, which will be $8+21\text{pF}=29\text{pF}$. Fig. 1 shows the basic circuit.

From the basic formula $f=\frac{1}{2\pi\sqrt{LC}}$ for the resonant frequency of a tuned circuit, it can be shown that the following relationships apply: $f=\sqrt{\frac{25330}{LC}}$, $L=\frac{25330}{f^2C}$, and $C=\frac{25330}{f^2L}$, where f is in Mc/s, L is in μH and C is in pF. From the known factors it can be calculated that $L=\frac{25330}{3.65^2\times 29}=65.6\mu\text{H}$.

Using the minimum and maximum values of the tuning condenser, the range of frequencies over which the circuit will tune can now be found. The lowest frequency will be tuned when the condenser is at its maximum value, i.e., C_{max} will tune f_1, and similarly C_{min} will tune f_2, the highest frequency. Therefore, C_{max} will tune to $f_1=\sqrt{\frac{25330}{65.6\times 50}}=2.78$ Mc/s, and C_{min} will tune to $f_2=\sqrt{\frac{25330}{65.6\times 8}}$ $=6.95$ Mc/s. This result makes it clear that the circuit tunes over a far wider range than required of it, from which it follows that this range will be accommodated over only a small part of the tuning scale. By calculating the actual values of C required to tune to the extremes of the required range, it is possible to predict the band-occupancy of the tuning scale. At 3.5 Mc/s, $C=\frac{25330}{65.6\times 3.5^2}$ $=31.5\text{pF}$, and at 3.8 Mc/s, $C=\frac{25330}{65.6\times 3.8^2}$ $=26.8\text{pF}$. So, a small change of capacity from 31.5pF to 26.8pF, amounting to only 4.7pF, covers the whole of the 3.5 to 3.8 Mc/s amateur band. Fig. 2 shows how this is covered by the capacity swing of the condenser, assuming that it has a straight-line law; it is quite clear from the sketch that very little bandspread has been achieved despite the relatively low value of maximum capacity used. The point to notice in Fig. 2 is that the amount of capacity used to tune, or spread, the required frequency range is small compared to the maximum capacity of the condenser. In other words, the bandspread ratio of the condenser is too small. If this ratio can be increased, the bandspread will be improved and the required range will occupy a greater proportion of the scale.

A means of doing this is shown in Fig. 3 where the tuning condenser, designated C_v, has the same values as before. A fixed capacitor C_t is now connected permanently in parallel with the tuning coil L, so that the effective tuning range of C_v is now 108 to 150pF, and the mid-point of the tuning range will be at the point where $C_t+C_v=129\text{pF}$. By making the same calculations as in the previous example it can be found that $L=14.7\mu\text{H}$, $f_1=3.39$ Mc/s, $f_2=3.99$ Mc/s, C_v tunes at 40pF for 3.5 Mc/s and at 19pF for 3.8 Mc/s, a swing of 21pF. This is more than four times the swing achieved with the circuit of Fig. 1, and the way the frequency range has been spread by the condensers is shown in Fig. 4, which is drawn to the same scale as Fig. 2.

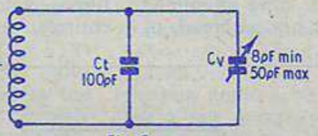


Fig. 3

Example of circuit to improve bandspread given by the basic circuit in fig. 1

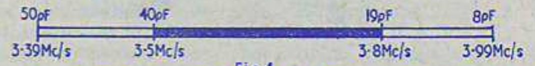


Fig. 4

Narrower frequency coverage & improved bandspread obtained with circuit in fig. 3

E720

One can, of course, make several more calculations on these lines, assigning different values to C_t until eventually optimum values are found for C_t and L to spread the frequency range over the whole of the 42pF swing of the tuning condenser C_v. However, this can be time-consuming, especially if several sets of calculations have to be made before the right values emerge. This process is little more than guesswork; it would be far more elegant to find a method, or generalized formula, that would enable one to hit the bull's-eye with one shot!

Consider Fig. 5, which is merely a reproduction of Fig. 3 with the values of C_t and C_v deleted.

Let C_t = value of parallel condenser, *including* the minimum capacity of C_v, in pF,
C_v = maximum capacity of tuning condenser, in pF,
L = inductance of coil, in μH,
f_1 = lowest frequency to which circuit tunes, in Mc/s,
f_2 = highest frequency to which circuit tunes, in Mc/s.

From the basic formula for resonant frequency of a tuned circuit, $f=\frac{1}{2\pi\sqrt{LC}}$, and since f is inversely proportional to the value of C, it follows that:

$$f_1=\frac{1}{2\pi\sqrt{L(C_t+C_v)}} \qquad (1)$$

$$\text{and } f_2=\frac{1}{2\pi\sqrt{LC_t}} \qquad (2)$$

Now let $k=\frac{f_2}{f_1}$, then from equations (1) and (2)

$$k=\frac{2\pi\sqrt{L(C_t+C_v)}}{2\pi\sqrt{LC_t}}$$

$$=\sqrt{\frac{L(C_t+C_v)}{LC_t}}$$

$$k^2=\frac{C_t+C_v}{C_t}$$

$$k^2C_t-C_t=C_v$$

$$C_t(k^2-1)=C_v$$

$$\text{so } C_t=\frac{C_v}{k^2-1} \qquad (3)$$

With this derived formula it is possible to calculate the value of C_t directly. This value can then be used in formula (4) below to find the inductance of the coil to tune the circuit to the desired range. The value of L in μH will be:

$$L=\frac{25330}{C_t\times f_2^2} \qquad (4)$$

In order to allow a margin for small errors it is as well to base the calculations on a capacity swing slightly less than the 42pF quoted in the previous examples. Giving a minimum value of 10pF and a maximum value of 48pF to C_v provides a capacity swing of 38pF, so the required bandspread should contain the frequency range within the limits of rotation of the condenser.

An example, using these values for C_v, will show how the work of designing the bandspread tuning is simplified. First, the value of k^2 is required for use in formula (3), so $k^2=\left(\frac{f_2}{f_1}\right)^2=1.18$. From (3), $C_t=\frac{C_v}{k^2-1}$ $=\frac{48}{0.18}=267\text{pF}$. From (4), $L=\frac{25330}{267\times 3.8^2}$ $=6.58\mu\text{H}$.

If the maximum value of capacity (C_t+C_v $=315$pF) is now used to find the lowest tuned frequency, and the minimum value ($C_t=267$pF) to evaluate the highest frequency, these will be found to be 3.497Mc/s and 3.80 Mc/s respectively, thus showing that the band is spread over practically the whole of the condenser swing.

It should be noted that the minimum value of C_t used in the calculations also includes the minimum capacity of C_v, so the actual value of C_t is 257pF. This could be made up by using a fixed capacitor of 220pF and a small trimmer of 50pF, to provide means of compensating for small stray capacities and for adjusting the alignment at the high-frequency end of the range. A coil with a dust-iron core similarly will permit the low-frequency end of the range to be aligned correctly.

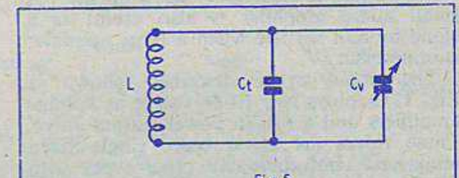


Fig.5
Circuit used for deriving formulae to calculate values for L & Ct

For making alignment adjustments the usual signal sources and output indicators can be used, though if the receiver is of the communications type the S-meter can become a convenient indicator of peak response. When adjusting the tuning circuits, start with the high-frequency end of the band, injecting a signal at 3.8 Mc/s and adjust the variable trimmer only for peak response, with the tuning condenser C_v set nearly to its minimum value. Then inject a frequency of 3.5 Mc/s, and with the tuning condenser set nearly to its maximum value adjust the core of L only for maximum response. These adjustments should be made several times to ensure that the frequency band is spread over as much of the tuning dial as possible, and until further adjustment of the trimmer and core make no marked improvement in peak responses. If a 100 kc/s crystal frequency marker with a 10 kc/s multivibrator stage locked to the crystal frequency is used

(*continued on page* 536)

AN ECONOMICAL 3-VALVE AUDIO AMPLIFIER

by

J. B. DANCE, M.Sc.

THE CONSTRUCTION OF A POWERFUL push-pull high fidelity audio amplifier always entails considerable expense. Whilst this may be well worth while to many people, there are others (especially newcomers to electronics and those not interested in music) who require a flexible circuit for a simple cheap amplifier for gramophone and radio reproduction which will give a few watts output at reasonably good fidelity. A small audio amplifier is also useful as a stand-by and for use when a large amplifier is unnecessary.

The circuit to be described (shown in Fig. 1) employs two EF86 valves as voltage amplifiers and a 6BW6 power output valve. These valves are noval based single-ended miniatures, but there are other types with similar characteristics which are quite suitable. The EF86 valves may be replaced by EF37A valves which have an international octal base and a top cap grid connection. Other octal types suitable for V_1 and V_2 are 6J7 and EF36 (VR56) which are obtainable cheaply on the surplus market but are more likely to introduce hum than the EF86 or EF37A. The 6SJ7 is a suitable single-ended octal type. The noval based 6BW6 output valve may be replaced by the octal 6V6 or, if the anode voltage does not exceed 250 volts, by the miniature 6AQ5 with a B7G base. If a 6BW6 is used the beam plates should be connected to the cathode; this is done internally in the other two types of output valve.

Negative feedback is used from the output transformer secondary to the cathode circuit of V_2. Any distortion in the last two valves or in the output transformer is reduced by the feedback, but it is nevertheless important to use a good transformer. The primary impedance of the transformer should be about 5,000 ohms and the secondary impedance should be about the same as that of the speaker to be used. The feedback circuit must be connected the correct way round; this is found by trial and error. If the gain is not greatly reduced when the feedback circuit is connected, or if the amplifier oscillates, the feedback wires (one is earthed) from the secondary of the output transformer should be reversed. The negative feedback greatly reduces distortion and extends the frequency range of the amplifier somewhat. It can, however, cause a great deal of distortion and instability if it is not connected correctly or if the output transformer is very poor. The amount of feedback is increased if the value of R_{15} (1,000 ohms in the circuit of Fig. 1) is reduced. The value of R_{15} may be slightly altered if better results can be obtained by so doing. In particular, if the output transformer secondary and speaker coil have an impedance greater than 4 ohms, the value of R_{15} may be increased somewhat. A 2,000 ohm resistor would be suitable for a secondary impedance of about 15 ohms. Negative feedback also has the advantage of improving the damping of the speaker cone electrically through the output transformer.

It is preferable, although not essential, to use high stability cracked carbon resistors for R_4 and R_{11} in order to minimise noise in the amplifier.

The input to the amplifier is via a co-ax cable fitting into a normal co-ax socket. The volume control potentiometer, R_1, should have a metal casing which can be earthed for screening purposes, and screened leads should be used to connect the input to the grid of V_1 in order to avoid hum pick-up.

Tone Controls

The treble-cut capacitors C_{10} and C_{11} are only intended to be used when very scratchy records are being played or when some top-cut is required to remove noise in radio reception. The larger capacitor gives quite a strong top-cut. The bass boost is useful to render sounds more natural when they are

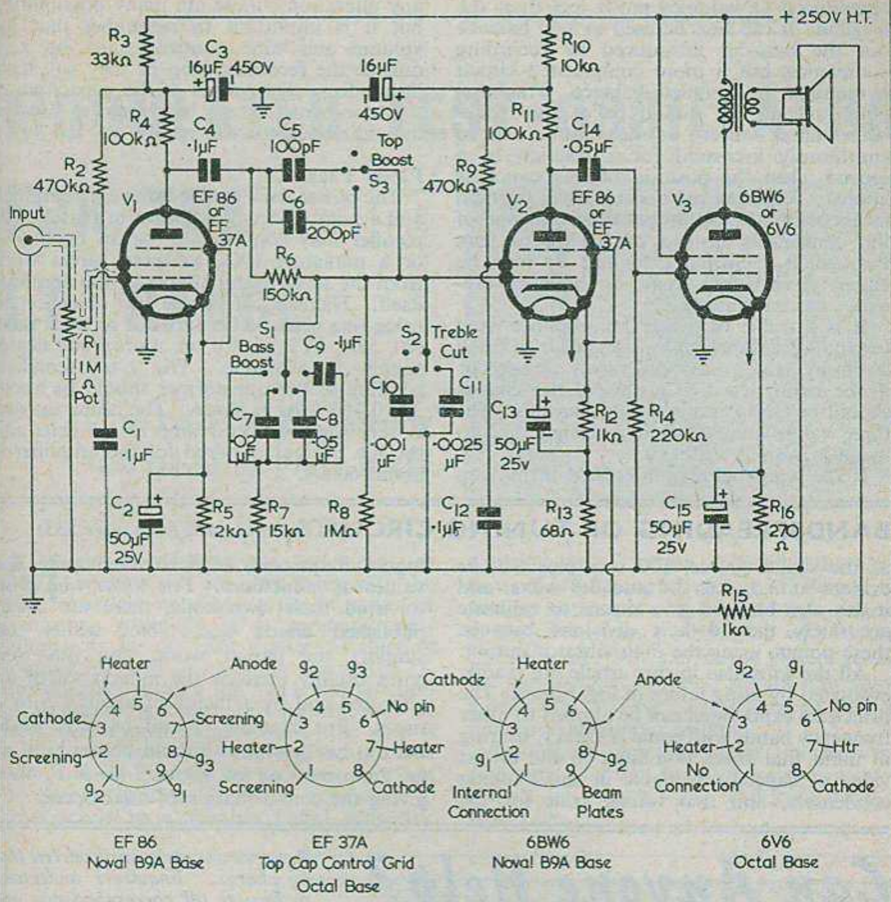


FIG.1.
Circuit Diagram of the Amplifier including valve base connections.

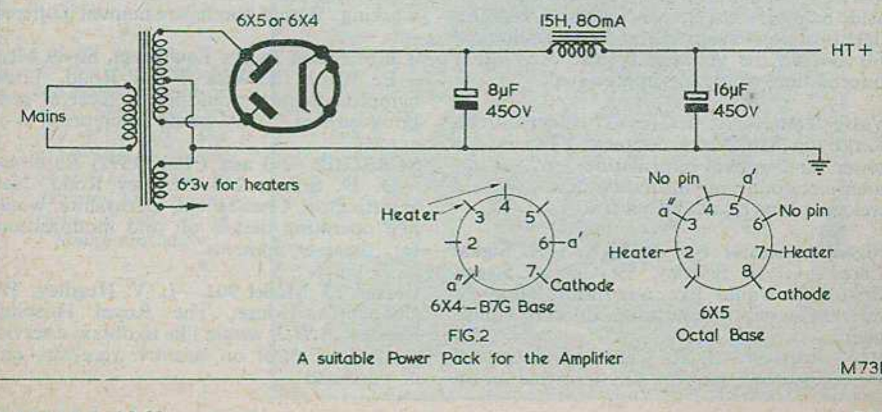


FIG.2
A suitable Power Pack for the Amplifier

M731

reproduced at volumes much less than the original. It can also be used to help balance out the bass-cut introduced by recording companies, but a more complicated circuit is required for complete balance. The bass-boost switch, S_1, should be of the make-before-break variety or the volume will be enormously increased for a fraction of a second when the position of this switch is altered. When the top boost is used, the high frequencies are able to pass through one of the condensers instead of having to pass through R_6. Switches S_2 and S_3 may be either make-before-break or break-before-make, as convenient.

It is possible to make the amplifier itself (excluding power pack) on a chassis as small as 5in by 2½in, but if octal valves are used or if the constructor is a novice, the chassis should be considerably larger than this. The three valves should be in a straight line to avoid undesired feedback.

If the constructor is interested in making any alterations, there are many possibilities, but it is important to remember that the volume and tone controls must be kept outside the feedback loop or they will have little effect. The values of the capacitors in the tone controls may be chosen to suit the individual constructor.

Power Pack

The power pack can be quite conventional, and a suitable circuit is shown in Fig. 2. The rectifier may conveniently be an octal 6X5 or a miniature 6X4, as these valves work from the same heater supply as the amplifier itself. There is, of course, no objection to using one of the other types of rectifier valve (80, 5Z4, 5Y3, etc.) if an appropriate heater supply is available. The h.t. secondary winding of the transformer should be about 300/0/300 volts at 80mA. The heater current is very slightly over 1 amp at 6.3 volts and the h.t. current required for the amplifier is about 60mA.

BANDSPREADING OF TUNING CIRCUITS

(*continued from page* 533)

as the signal source, 100 kc/s pips will be evident at 3.5, 3.6, 3.7 and 3.8 Mc/s, and it can also be used as a means to calibrate accurately the 10 kc/s divisions between these points, using the multivibrator output.

All the formulae in this article are readily evaluated by using tables of logarithms. The principles expounded can be applied to other frequency bands with equal accuracy, bearing in mind that there is a limit to the lowest value of capacity available in small tuning condensers, and that tuning coils for the higher frequencies tend to have quite low values of inductance. For those who wish to wind their own coils, there are many published charts and tables which can simplify the design work, and dust-iron cores usually increase the inductance of an air-cored coil by a factor of about 1.5 to 2 times. For example, a coil of, say, 10μH with a dust-iron core should be designed as an air-cored coil of about ·7 to 8μF, thus giving the core a margin of adjustment.

Can Anyone Help?

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

Wireless Station No. 19.—N. Brown, Winslade School, Clyst St. Mary, Devon, requires details of conversion of the above equipment for use on the amateur bands. Any other information would be appreciated.

* * *

Valve Tester.—R. Evans, 27 Elder Street, Kirkby-in-Ash, Notts, desires to build a valve tester and seeks information on various inter-electrode and insulation tests. Would welcome any circuit diagrams.

* * *

Signal Generator type 1-130-A, U.S. Signal Corps.—G. B. Brierley, 99 Chessel Street, Bristol 3, would like any information or relevant service publication on this equipment.

R107 Receiver.—J. R. Clarke, 206 Queens Drive, Bedford, requires any information on converting this receiver for amateur band working. Would purchase a manual if offered.

* * *

T.B.S. Series Tx/Rx Equipment, 60-89 Mc/s.—E. Webb, 9 Wick Farm Road, Littlehampton, Sussex, would like to receive "gen" book on this R.C.A.-made equipment.

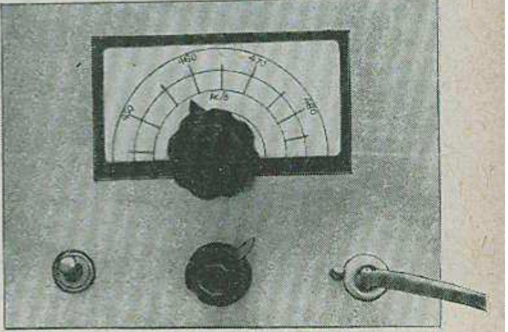
* * *

SCR522(BC624) and P104 (1392) Receivers.—D. D. Smith, 245 Handley Road, New Whittington, Chesterfield, Derbyshire, would like operating details of, and modifications for, these equipments.

* * *

Cossor TV Model 901.—L. V. Headley, The Chaplain's House, The Royal Hospital, London, S.W.3, would like to obtain a service manual or sheet on this t.v. receiver—hire or purchase.

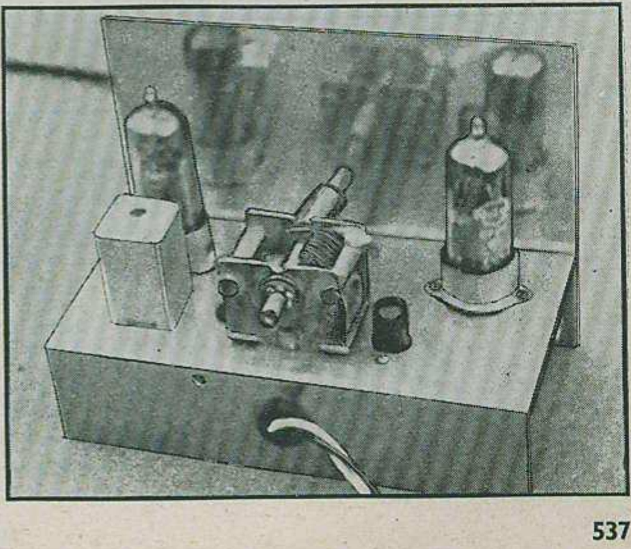
MODULATED TEST OSCILLATOR FOR THE I.F. RANGE



By **David Noble, G3MAW**
and **David M. Pratt, G3KEP**

Many amateur service engineers and constructors are often faced with the problem of aligning the i.f. strips of receivers. Although it is generally considered to be an easy matter to align a receiver i.f. strip by carefully tuning the i.f. transformers in turn for maximum strength of an incoming signal, this method may be overruled if each transformer of the strip is a long way out. This can well be the case with a newly constructed receiver, and it is necessary, therefore, to either possess or to have access to a reliable signal generator covering the i.f. range. Basically, the ideal method of aligning a receiver i.f. strip is to feed on to the grid of the mixer stage a signal at the i.f. frequency modulated with a continuous note. An a.c. meter placed across the loudspeaker terminals should now show a deflection, and the i.f. transformers may be tuned for maximum reading.

The signal generator need not be very elaborate, and can be made as shown on a chassis 3in x 6in x 1½in. The front panel is 4½in x 6in.



In this rear view of the generator can be seen the oscillator coil on the left. The modulation level potentiometer is mounted just to the right of the main tuning condenser

An EF80 operates as a Clapp oscillator variable from 445 to 490 kc/s. The coil L consists of one bank of an i.f. transformer. This was carefully removed from its original former and slid on to a smaller former of the same diameter. For constructors wishing to wind their own coil, it consists of 270 turns of 20/0.002 Litz wire wavewound, $\frac{5}{16}$in bank-width, and on a $\frac{9}{32}$in diameter former. The coil is permeability tuned with a dust iron core. Another EF80 is employed as a 1,000 c/s phase-shift oscillator. The output of this is fed via a condenser to the screen grid of the r.f. oscillator, thereby applying sine wave modulation. The degree of modulation can be adjusted by means of the potentiometer VR_2. Instead of the usual r.f. choke in the cathode of the Clapp oscillator, a 10kΩ carbon potentiometer is fitted, the slider being connected via a 100pF condenser to the output socket. Although this does not permit the output level to be accurately calibrated, it enables a variable signal level to be obtained. It is necessary to calibrate the frequency of the generator using either a receiver which covers the normal i.f. range, or by beating it with another signal generator which is calibrated. The writers' instrument was calibrated using an R.1155 receiver.

Power Supplies

The signal generator may be run from any

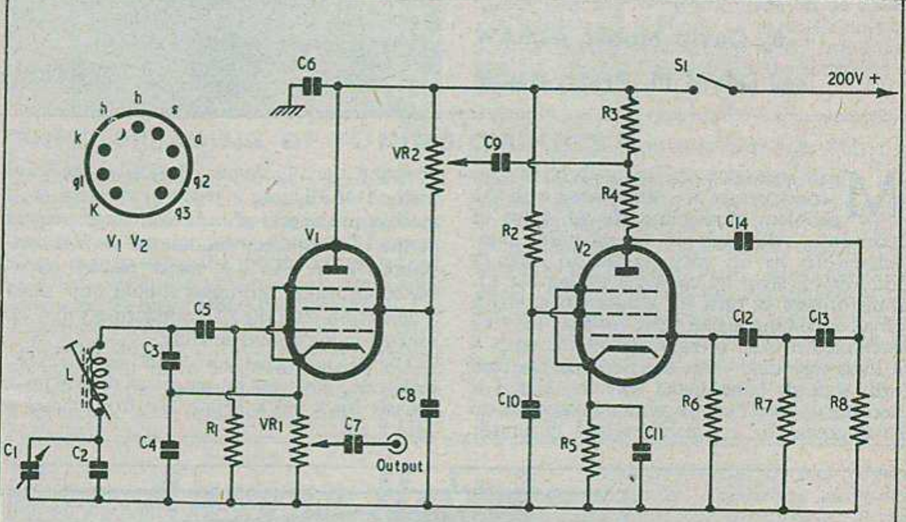


Fig. 1. Circuit diagram of the I.F. Range Modulated Test Oscillator

E735

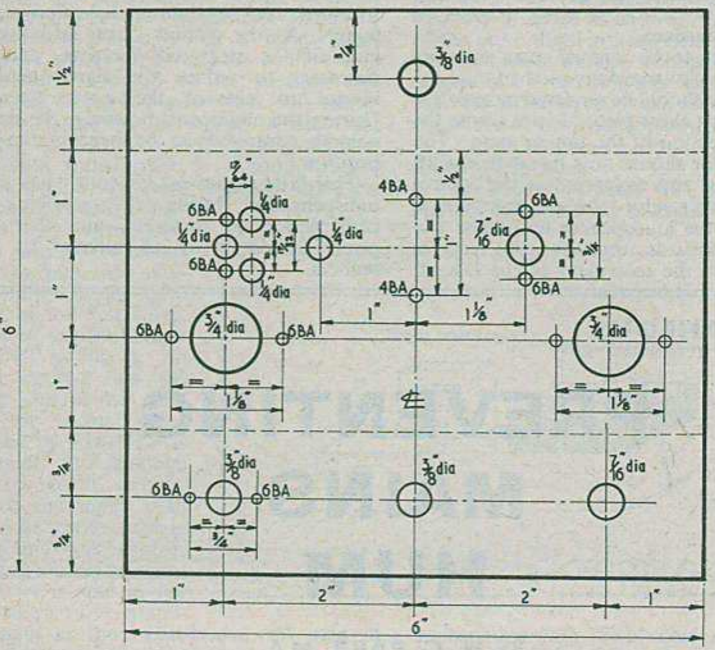
Components List

Resistors
- R_1 100kΩ
- R_2, R_5 1,000Ω
- R_3 4.7kΩ
- R_4 10kΩ
- R_6, R_7, R_8 100kΩ

Miscellaneous
- VR_1 10kΩ carbon pot.
- VR_2 100kΩ carbon pot.
- S_1 S.P.S.T. toggle switch
- V_1, V_2 Valves type EF80
- L See text

Capacitors
- C_1 75pF variable
- C_2 220pF silvered mica
- C_3, C_4 1,000pF silvered mica
- C_5 100pF silvered mica
- C_6 0.01μF paper
- C_7 100pF ceramic
- C_8 2,000pF ceramic
- C_9 0.02μF paper
- C_{10} 0.1μF paper
- C_{11} 25μF, 25 volt electrolytic
- C_{12}, C_{13}, C_{14} 500pF silvered mica

Also required:
Two B9A valveholders
Co-axial socket
Chassis and front panel



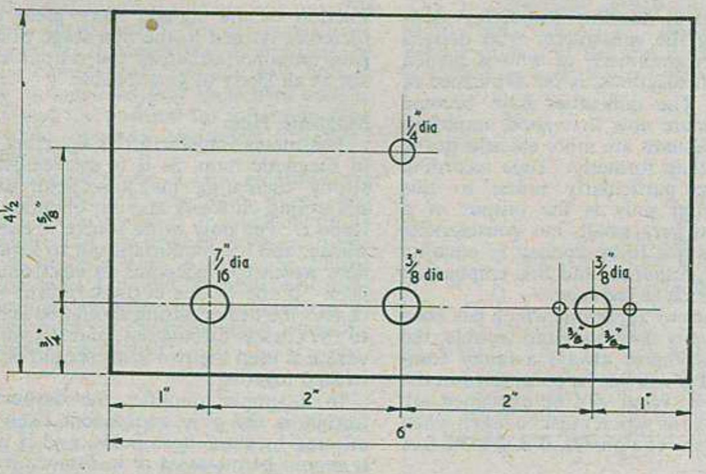


Fig. 2. Drawing showing chassis drilling dimensions. The chassis sides should be bent upwards on the dotted lines shown

Fig. 3. Dimensions for drilling the aluminium front panel

suitable power supply capable of providing 6.3 volts at 0.6 amp, and about 200 volts at 30mA.

Alignment Procedure

The receiver to be aligned must have its tuning condenser vanes fully meshed, and the local oscillator should be rendered inoperative by connecting a short piece of wire across the appropriate section of the tuning gang. The signal generator should now be set to the i.f. of the receiver, and connected to the control grid of the mixer valve. An a.c. voltmeter is connected to the loudspeaker terminals, and working backwards through the receiver beginning with the secondary of the last i.f. transformer, and ending with the primary of the first transformer, the cores should be trimmed for maximum deflection of the meter. As the circuits come into line, the gain of the strip will increase, and it is necessary to reduce the signal generator output to prevent the a.v.c. operating. During the alignment, however, the receiver volume control must be kept in the same position.

This little alignment generator has proved indispensable during the servicing and construction of receivers, and the circuit given should prove of interest to many readers.

MISCELLANEOUS

PREVENTING MAINS HUM

By **H. C. PARR, M.A.**

One of the biggest problems confronting the constructor who designs his own amplifiers, or who is guided only by circuit diagrams, is the avoidance of mains hum. The difficulties have become much more acute now that good amplifiers and speaker systems are more efficient in the bass register than formerly. Tape recording amplifiers are particularly prone to this trouble, for not only is the output of a playback head very small, but considerable bass emphasis has to be applied to equalise the frequency response, and this emphasises the hum as much as the bass.

When a piece of apparatus which has been working properly develops hum trouble, the explanation is almost always a faulty component, and this will not be considered in the present article. What will be explained are all the precautions which must be taken when constructing new equipment, if it is to be free from hum.

There are four distinct causes of hum, and these will be dealt with in turn. They are respectively (1) electromagnetic induction, (2) inadequate h.t. smoothing, (3) electrostatic induction, and (4) the incorrect earthing of components. It is essential to realise that hum is of importance in any part of a circuit only when its intensity is an appreciable fraction of the signal. Very great care is therefore needed in the first stage of a high-gain amplifier, whereas the output stage is not at all likely to give trouble.

Magnetic Hum

The mains transformer is the chief source of magnetic hum, as it is surrounded by a strong oscillating magnetic field, and the smoothing choke is also an offender in this respect. The only other source is the heater wiring, and it is important not to form loops here which can generate an electromagnetic field. If the heater current returns via the chassis the heater wiring should be kept close to the chassis throughout, and if twin heater wiring is used the two leads should be tightly twisted together.

In a simple amplifier the output transformer is the only component likely to be affected by these hum fields, and if possible it should be mounted at a distance from the mains transformer and choke. When this cannot be done, a satisfactory hum level can usually be achieved by adopting a suitable orientation for the components involved. The choke will generally have no effect if it is mounted with its axis at right-angles to that of the output transformer, but a similar arrangement between the mains and output transformers will not always prove adequate. However, this arrangement always works if the latter lies in the "equatorial plane" of the former, as shown in Fig. 1. In any case, the layout can be tested as soon as the transformers are mounted on the chassis, and before the wiring is begun. It is only necessary to connect the mains transformer correctly to the mains, and the secondary of the output transformer to a good speaker system, and if any hum is heard some repostioning is called for.

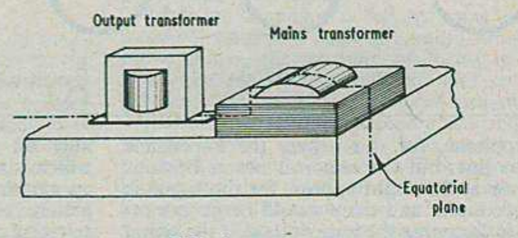


FIG. 1.

The only other part of a normal amplifier likely to pick up magnetic hum is the grid circuit of the first valve, that is to say the circuit ABCDEF in Fig. 2. To guard against this the wiring should be such that the actual area enclosed by ABCDEF is as small as possible, with the earth connection of the input, AB, kept close to the cathode wiring and bias resistor.

If any inductive components are used in the early stages of an amplifier, such as the treble-boost coil used in some tape recorders, these present a special problem. Screening cans of mu-metal are usually essential, and the amateur is not able to fashion these himself, for mu-metal loses its properties if disturbed by cutting or drilling. Components of this sort should also be mounted so that their axes can be rotated, and the position for minimum hum found when the whole equipment is finished and working.

The playback heads of tape recorders are highly sensitive to magnetic hum, and various devices are used by manufacturers to minimise this. Whenever a mains transformer is to be housed in the same cabinet as a tape deck, it should be capable of rotation through 180° so that the position of minimum hum can be determined when the equipment is complete.

H.T. Smoothing

The conventional power pack, smoothed by two electrolytic condensers and either a choke or resistor, supplies high tension current with a sufficiently low ripple content to feed the output valve satisfactorily, but if this were applied directly to the earlier valves it would almost certainly introduce hum. It is fortunate, therefore, that the decoupling circuits of these valves form excellent hum-rejection filters, and will generally reduce the h.t. ripple adequately even for the first valve. If this is not the case, the fault can always be remedied by arranging the decoupling resistors in series as shown in Fig. 3 instead of the more usual arrangement. This will, of course, reduce the h.t. voltage in the earlier stages, but if the resistors are calculated so that this reduction does not exceed, say, 25%, the effect of this will not be noticeable.

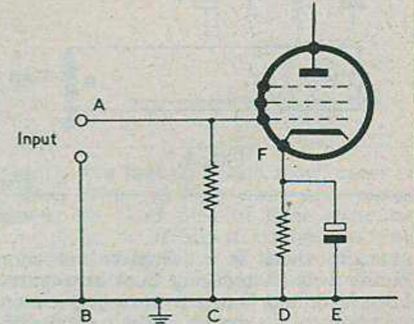


FIG. 2.

Electrostatic Hum

This source of hum will be familiar to anyone who has tried using a pick-up or microphone with an unscreened cable, and Fig. 4 should help to make its origin clear. An unscreened microphone circuit is shown, with a mains lead in the vicinity; and the small capacitance, C, which will exist between this and the live microphone lead, is shown as a dotted condenser. C and R together form a potential divider supplied with 250 volts a.c., so that a certain small fraction of this voltage appears across R and gives rise to the characteristic hum. This fraction is proportional to R, and this explains why a low impedance circuit is less susceptible than a high one. A reduction in hum sensitivity can be obtained by incorporating a step-down transformer in the microphone, for this lowers the impedance of the line; but the reason is not as obvious as may at first sight appear, for the signal is also reduced, and there would be no advantage in lessening the hum voltage if the signal voltage were lessened in proportion. However, those familiar with line transformers will know that the reduction in impedance is proportional to the *square* of the reduction in signal voltage, and so the hum is reduced *more* than the signal.

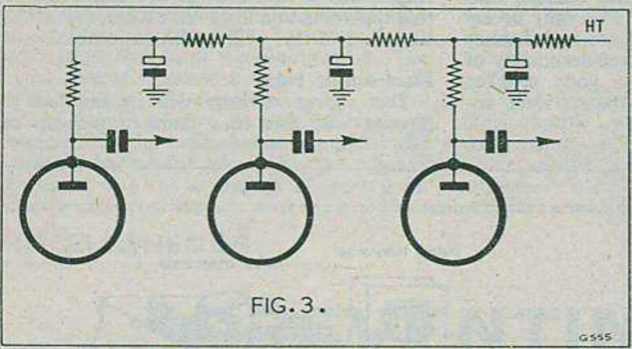


FIG. 3.

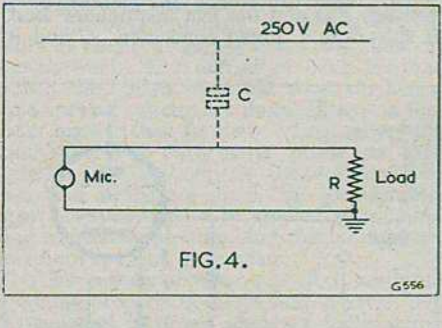


FIG. 4.

Luckily there is a simpler and more effective way of reducing hum in a microphone lead, and that is to surround it along the whole of its length with a conducting sheath connected to the chassis. Twin-screened cable is sometimes used for this, but unless a "balanced" input is required it is simpler to employ single-screened cable with the outer conductor serving as the earth return, as shown in Fig. 5.

This process of screening is of general application, and whenever electrostatic hum is being introduced into some part of an amplifier it can be removed by enclosing the sensitive part in a metal container connected to the chassis. In a high-gain amplifier every signal lead more than an inch or so in length in the early stages must be of screened cable with the sheathing earthed. The earthing should be done at one point only, and if the sheath is not insulated should not be allowed to come into contact with the chassis at any other point. If electrostatic hum persists, a simple aluminium box around the whole of the wiring associated with these early stages should effect a cure. If it does not, the cause must be from within, and is probably an unscreened length of signal lead which is too close to the heater wiring. Such an aluminium box does not need to be completely closed, and often an undershield covering the whole of the chassis will be found sufficient.

It is easy to find the parts of a circuit which are sensitive to electrostatically induced hum. Taking care not to touch the chassis, if one explores with a finger or a metal rod held in the hand the hum becomes more intense as sensitive parts are approached, and so indicates where further screening is desirable. If it is found that a valve responds in this way it is advisable to shield it with a metal screening can.

The above explanation of this type of hum assumes that the chassis is at a steady potential and that the hum producing elements are mains leads either in the amplifier itself or in the surroundings. When a chassis is properly earthed, for instance through the third pin of a mains plug, this is in fact the case, but when an amplifier is not earthed another factor assumes importance, for the potential of the chassis itself may then oscillate widely at mains frequency. This has the same effects as if the amplifier were at constant potential and *everything* else in the room were oscillating, and this explains why the simple process of connecting to earth will often cure a hum. (It must be remembered, of course, that a.c./d.c. apparatus not incorporating a mains transformer cannot be directly earthed). However, if earthing is inconvenient or impossible for one reason or another, a miraculous cure can often be produced by reversing the mains plug. Another trick that sometimes works is to join the chassis to one or other of the mains leads by a condenser. The insulation of such a condenser must be above suspicion, and its capacity should not exceed .01μF.

One of the most difficult aspects of valve manufacture is to minimise the hum induced by the heater and its pins, and most of the older types of valve are not good enough in this respect to allow their use in the first stages of a high gain amplifier. Special low-hum valves, such as the EF86 and ECC83 are now manufactured for these applications. A centre-tapped mains transformer gives an improvement when valve hum is troublesome, but a better system is to wire a "humdinger" potentiometer of about 20Ω resistance across the heater line with the movable contact earthed. This can then be adjusted when the amplifier is ready for use.

Earthing

To understand how the earthing of components can introduce hum, one must be rid of the notion that all points on a chassis are at the same potential. If the valve heaters are earthed to the chassis, it is clear that heavy hum currents must be flowing through it, but even when twin wiring is used for the heaters there will still be hum currents emanating from the smoothing and decoupling condensers, and flowing back to the power pack through the chassis. Fig. 2 will help to explain how this can introduce hum. Suppose the line BE represents a section of the chassis, and that a hum current is flowing between B and E. Now although the resistance between B and E will be very low it can never be exactly zero, and some potential difference exists between these two points. As this is in the circuit ABCDEF it is impressed on the grid of the valve. A hum voltage as small as a millionth of a volt introduced in this way into the first valve of a tape amplifier can be audible in the output.

To guard against this, B, C, D, and E must all be connected to *one point*, which either lies on the chassis or is connected to it by a single thick wire. This is shown diagrammatically in Figs. 5 and 6. If it is wished to deal with the second stage in the same way it is essential to use the same point on the chassis for the two stages, and a fact that is often overlooked is that the decoupling condenser of the first stage must also be earthed at this point if no hum is to be introduced *between* the stages. However, if care is taken to minimise hum currents in the chassis, by using twin heater wiring and by careful design of the power pack, paying particular attention to the ripple current flowing to earth from the reservoir condenser, it should rarely be necessary to take any special precautions in the second stage of a normal amplifier.

Connecting Two Units

When an amplifier is fed by some other piece of equipment such as a radio tuner or pre-amplifier, the earthing problems in the two units can become difficult, and several different cases must be considered separately.

If the source of the signals is a unit requiring no power, such as a pick-up or the playback head of a tape deck, it is connected to the earthing point of the first stage via the screen of the connecting cable, as shown in Fig. 5. The only point needing attention is that the metal frame of the playing desk or tape deck must also be earthed to the amplifier, but that an "earth loop" must be avoided. Thus, if both units are earthed through the third pins of their respective mains plugs, no additional connection must be made. But in Fig. 5, if the gramophone motor assembly is not so earthed, it should be connected to the point E as shown.

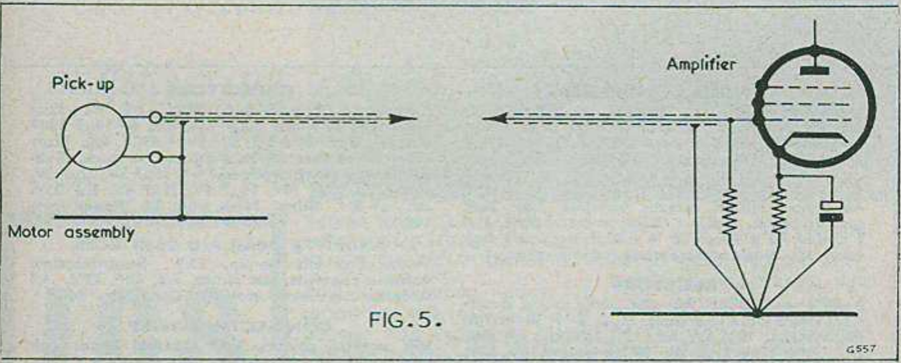


FIG. 5.

When the signal source is a radio tuner or pre-amplifier which does require power, then *provided it incorporates its own power pack* the previous paragraph still applies. The screen of the connecting cable will therefore be joined to both chassis, unless this produces an earth loop, in which case it will be joined only at the main amplifier end.

(*To be concluded*)

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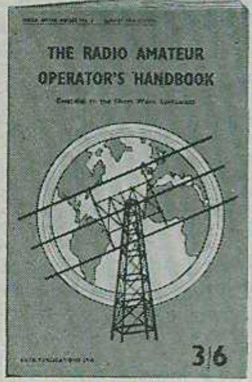
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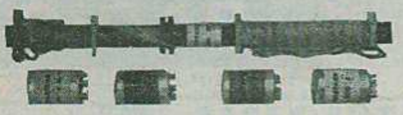

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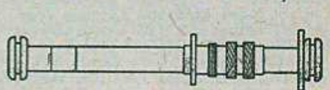

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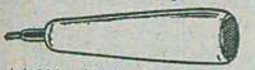
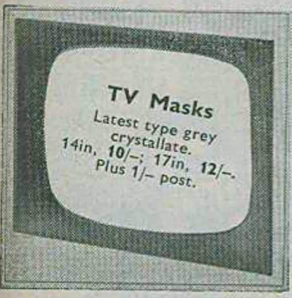


Model 39/1 this is ideal for tape or general amplifiers, complete with screened lead **39/6**, plus 1/– post.



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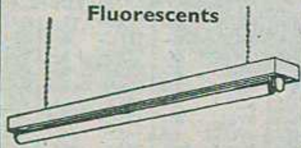

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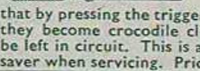

The advantage of these test prods is that by pressing the trigger at the side they become crocodile clips and can be left in circuit. This is a great time saver when servicing. Price **15/–** pair.

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1½ amp	**3/6**
2 amp Q.M.B.	**5/6**
5 amp	**8/6**
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15 amp—wall mounting ...	**27/6**

Note all are skeleton type similar to illustration except the wall mounting type which is encased in metal box with scale and pointer.

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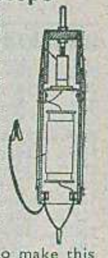
1 pole 3 way, **1/6**; 1 pole 5 way, **2/–**; 1 pole 11 way, **2/6**; 2 pole 2 way ceramic, **2/6**; 2 pole 4 way, **2/–**; 2 pole 6 way, **2/6**; 2 pole 8 way, **3/6**; 2 pole 11 way, **3/6**; 2 pole 12 way, **4/6**; 3 pole 3 way, **1/6**; 3 pole 6 way, **3/6**; 4 pole 4 way, **3/–**; 6 position shorting, **2/–**; 6 pole 3 way, **2/6**; 6 pole 3 way ceramic, **3/6**; 8 pole 2 way, **2/–**; 9 pole 3 way, **2/6**; 12 pole 2 way, **2/–**.

Radio Stethoscope



This can be slipped into the pocket rather like a fountain pen. With it in most districts a receiver can be checked from the grid of the first valve right through to the output without a signal generator, the stethoscope will operate in both L.F. and R.F. circuits without alteration. It is a complete fault-finder.

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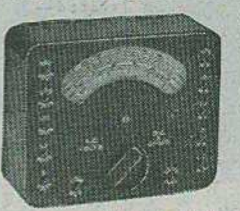

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0B2	10/–	5R4G	8/6	6C5	5/–	6SQ7	6/–	12SC7	6/–	83	10/–	DL91	7/–	KT66	12/6
0Z4	5/–	5V4	10/–	6F6	7/6	6SR7	6/–	12SG7	6/–	807	5/–	DK92	7/6	KTW61	6/6
1A5	5/–	5X4G	10/–	6F8	7/6	6SS7	6/–	12SH7	6/–	807USA	7/6	DL94	7/6	KTW63	5/–
1A7	12/6	5Y3GT	6/–	6F12	5/–	6U4	12/6	12SJ7	6/–	AC/SG	10/–	DM70	8/6	MVS PEN	
1C5	10/–	5Y4G	10/–	6F32	7/6	6U7	5/–	12SK7	6/–	AC2PENDD		EB91	5/–		10/–
1H5	10/–	5Z3	10/–	6F33	5/–	6V6G	6/–	12SQ7	8/6		12/6	EBC33	6/6	MS PEN	10/–
1L4	5/–	5Z4G	8/6	6J5M	5/–	6V6GT	7/6	14S7	14/–	AC/PEN	10/–	EF50	4/–	MU14	7/6
1LD5	5/–	5Z4M	10/–	6J7M	7/6	6V6M	10/–	25A6	10/–	AC/VP1	10/–	EL32	5/–	MX40	10/–
1LN5	5/–	6A7	9/–	6K7G	5/–	6X4	6/–	25L6	10/–	AC/VP2	10/–	EL33	12/6	N14	10/–
1N5	10/–	6A7	9/–	6K7M	7/6	6X5GT	5/–	25Z4	9/–	AR8	5/–	EM34	7/6	PEN4VA	
1R5	7/–	6AB8	10/–	6K8M	10/–	7A7	9/–	25Z5	9/–	AZ31	10/–	EM80	10/–		10/–
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3A4	7/–	6AL5	5/–	6SA7	6/–	7Y4	7/–	42	7/6	DAF91	7/–	FW4/800		PX25	12/6
3A5	9/–	6AM5	5/–	6SC7GT	7/6	9D6	5/–	43	10/–	DCC90	9/–		10/–	QP21	5/–
3D6	4/6	6AM6	5/–	6SG7	6/6	12AH7	6/–	50B5	10/–	DF91	7/–	GZ32	11/–	QP25	6/6
3Q4	7/6	6B8G	4/6	6SH7	5/–	12AU6	9/–	50C5	10/–	DH63	7/6	GZ34	11/–	SP4	10/–
3Q5	9/–	6BR7	12/6	6SJ7	6/–	12BE6	10/–	75	10/–	DK32	12/6	HL23/DD		TDD4	10/–
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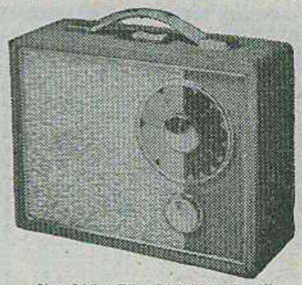

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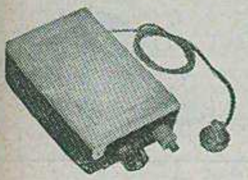

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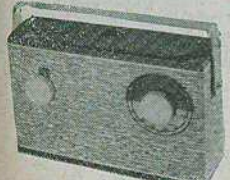

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continued on page 559

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1S5	**6/6**	6SK7M	**6/6**	DL70	**5/–**	GZ32	**11/6**
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3A4	**4/6**	6ST7	**8/6**	EAF42	**9/–**	OA2	**8/–**
3A5	**9/–**	6V6G	**7/6**	EB34	**2/–**	PCC84	**8/6**
3Q4	**6/6**	6X4	**5/6**	EB91	**4/–**	PCC85	**9/–**
3S4	**8/6**	6X5GT	**6/6**	EBC33	**5/–**	PCF80	**9/–**
3V4	**7/6**	7B7	**8/–**	EBC41	**8/6**	PCF82	**9/–**
5R4GY	**9/6**	7C5	**8/–**	EBF80	**9/–**	PCL82	**11/6**
5Y3GT	**7/6**	7C6	**8/–**	EBF89	**9/6**	PEN25	**4/–**
6AC7M	**5/–**	7S7	**9/6**	EC80	**12/6**	PL81	**12/6**
6AG5	**3/6**	7Y4	**8/–**	ECC82	**6/6**	PL82	**8/6**
6AK5	**5/–**	12A6M	**6/6**	ECC83	**7/6**	PL83	**8/6**
6AL5	**4/–**	12AT6	**8/6**	ECC84	**9/–**	PY80	**7/–**
6AM6	**4/–**	12AT7	**8/–**	ECC85	**8/6**	PY81	**8/6**
6AQ5	**8/6**	12AU7	**6/6**	ECF80	**10/6**	PY82	**7/6**
6AT6	**7/6**	12AX7	**7/6**	ECF82	**11/6**	PY83	**8/–**
6AU6	**7/6**	12AU6	**9/–**	ECH42	**9/–**	TT11	**4/–**
6B8G	**3/6**	12BE6	**8/6**	ECH81	**10/–**	UAF42	**9/–**
6BA6	**7/6**	12C8M	**7/6**	ECL80	**10/6**	UBC41	**8/6**
6BE6	**7/6**	12K7GT	**6/6**	ECL82	**11/–**	UBF89	**9/6**
6BH6	**6/6**	12K8M	**10/–**	EF36	**4/–**	UCC85	**9/6**
6BJ6	**7/6**	12Q7GT	**6/6**	EF39	**4/6**	UCH42	**9/–**
6BR7	**10/6**	12SC7M	**2/6**	EF41	**9/6**	UCH81	**9/6**
6C4	**4/–**	12SJ7M	**5/–**	EF50	**2/6**	UF41	**9/–**
6F32	**4/–**	12SK7M	**5/–**	EF50(S)	**4/6**	UF42	**8/–**
6F6M	**5/6**	12SQ7M	**8/6**	EF80	**6/6**	UF89	**9/–**
6J5GT	**4/6**	35Z5GT	**8/6**	EF85	**9/6**	UL41	**9/–**
6J5M	**5/–**	35Z4GT	**7/6**	EF86	**11/–**	UL84	**9/–**
6J6	**4/–**	42	**7/6**	EF89	**8/6**	UY41	**7/6**
6J7G	**7/6**	50L6GT	**9/6**	EF91	**4/–**	UY85	**8/6**
6K7G	**3/6**	80	**6/6**	EL32	**4/–**	UABC80	**10/6**
6K8G	**6/–**	446A	**10/6**	EL41	**9/6**		
6K8M	**10/6**	830B	**15/–**	EL84	**9/–**	VLS631	**12/6**
6H6M	**2/6**	866A	**15/–**	EM80	**9/6**	VP23	**4/–**
6L6G	**8/–**	959	**5/–**			VR150/30	**7/6**
6L6M	**10/–**	1629	**4/–**	EY51	**10/6**		
6Q7G	**7/6**	5763	**10/6**	EY86	**10/6**		
6Q7GT	**9/6**	ARP12	**4/–**	EZ40	**6/6**	VS70	**3/–**
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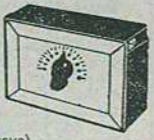

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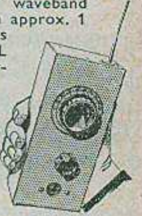

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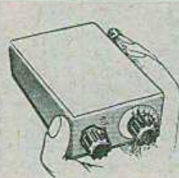

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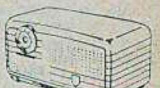

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continued from page 557

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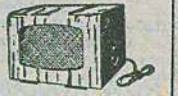

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5Z4G	9/–	12BH7	10/6	DL96	8/–	EZ81	7/–
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6AL5	5/6	12K8GT	13/6	EBC41	9/6	PL82	10/6
6AT6	7/6	12Q7GT	8/6	EBF80	10/6	PY81	8/–
6BA6	8/6	25A6G	10/6	ECC81	7/6	PCC84	10/6
6BE6	7/6	25L6GT	9/–	ECC82	7/6	PCF80	10/6
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6J7GT	8/6	807	6/9	ECH81	10/6	UBC41	10/–
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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

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