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The

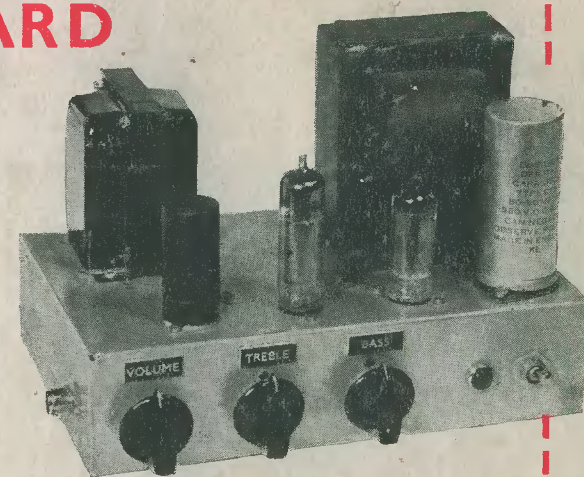
RADIO Constructor

FOR THE RADIO AND TELEVISION ENTHUSIAST

VOLUME 9 NUMBER 9 APRIL 1956

Building the

MULLARD 3 VALVE 3 WATT HI-FI AMPLIFIER



WITH POINT-TO-POINT WIRING DIAGRAM

Also in this issue

- ARGONAUT A.M./F.M. TUNER/RECEIVER, Part 2
- TRANSISTORETTE RECEIVER, Part 3
- BAND III TELEVISION, Part 10
- DESIGN CHARTS FOR CONSTRUCTORS, No. 5
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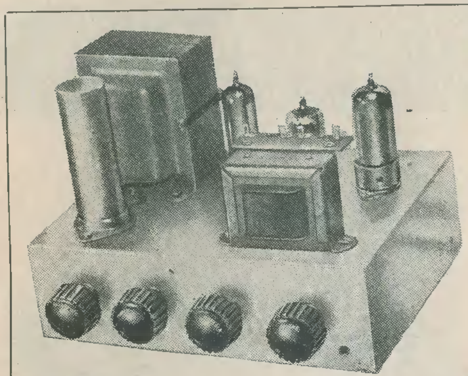

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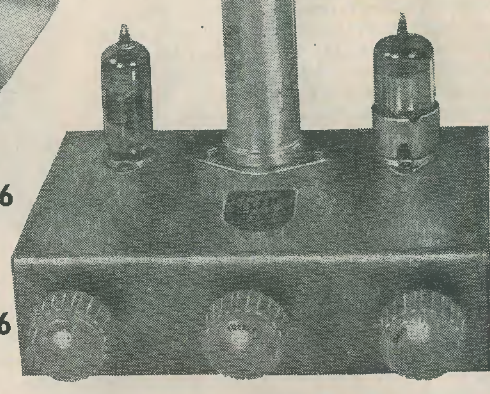

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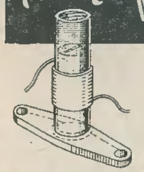

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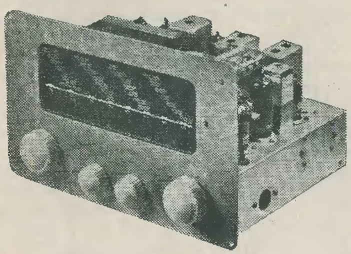

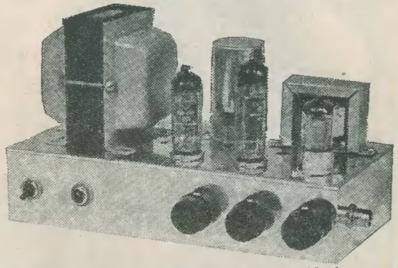

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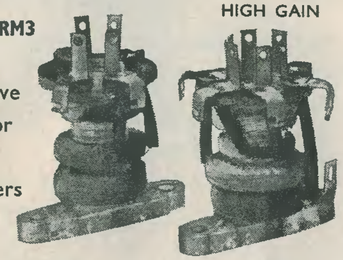

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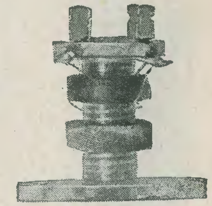

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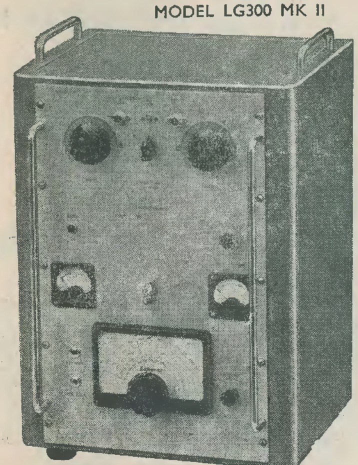

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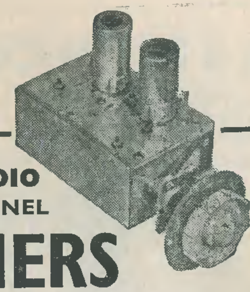

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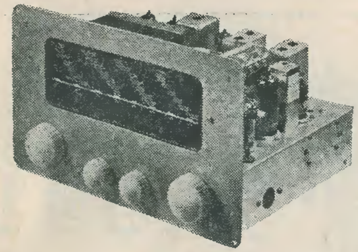

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VOL. 9. NO. 9

APRIL 1956

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

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

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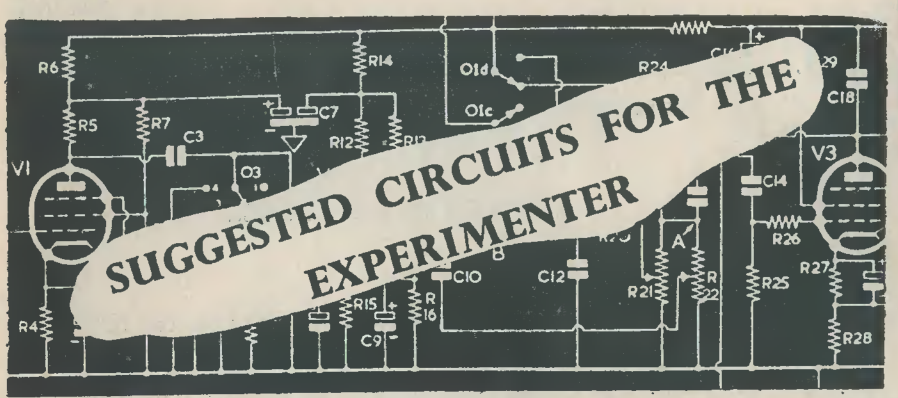

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No. 65. DELETING HUM FROM A.F. AMPLIFIERS

One of the greatest difficulties experienced in the design of sensitive a.f. amplifiers is the necessity of reducing hum pick-up to negligible proportions. This trouble shows itself at its worst in the input stage of the amplifier, and it is at this point that most care has to be taken in design and during construction.

Normally, hum pick-up in the input stage of an amplifier can be reduced by a combination of several well-established techniques. These include the magnetic shielding of inductive input components such as microphone transformers, etc.; the filtering of h.t. supplies; and the use of efficient electrostatic screening. However, although these steps can considerably ease hum difficulties there still remains one potential source of trouble, this being hum pick-up from the heater supply. The most sensitive point of a conventional a.f. amplifier appears at the grid of the input valve, this being normally connected to chassis and, thence, its cathode, via a relatively high value of impedance. Thus, whilst it is simple to keep the cathode of the input valve at chassis potential so far as hum voltages are concerned, it is extremely difficult to similarly treat the input grid and its wiring. In consequence, hum may quite easily be picked up by the input grid wiring due to stray couplings to the heater wiring. Even with modern low-hum pentodes the possibility of hum pick-up cannot be entirely rejected, and it is often found that amplifiers employing these valves still rely on such devices as humdingers to reduce hum to the lowest practicable level. As readers who have had experience of amplifier work may be aware, humdingers and similar devices are not always efficacious.

It follows from the above that, although it is possible to amost completely eradicate hum from the input stage of an a.f. amplifier by means of screening and h.t. filtering, some pick-up must almost always exist due to the presence of a.c. on the heater. Attempts have been made in the past to supply the heater of the input valve with d.c., this being usually obtained by rectification of a.c. from the mains supply. Unfortunately, the heavy filtering required for such circuit arrangements, combined with their expense and relative inefficiency, render them unattractive. A quite different approach, and one which has been relatively unexplored to date, is the process of heating the first valve with an r.f. voltage. At first sight, this might also appear unattractive because of the possible difficulties of obtaining the power required economically, both with regard to current consumption and cost of components. However, due to the recent issue by a manufacturer of an r.f. transformer designed especially for this purpose, it is now possible to heat the input valve of an amplifier with r.f. current not only reliably but cheaply as well. The component concerned is the transformer type "S.S.O." manufactured by the Teletron Co., and it has additional applications which will be covered later on in this article. This month's article is concerned with practical arrangements employing the new transformer.

The Circuit

The basic circuit in which the Teletron transformer may be employed is illustrated in Fig. 1. In this diagram it will be seen that the transformer consists essentially of a tuned primary coil connected in a Hartley oscillator circuit, its secondary being connected directly to the heater of the valve it is intended to drive. The oscillator valve coupled to the primary of the transformer can consist of any output pentode or tetrode capable of developing 2.5 watts or more at 240 volts anode voltage. Such valves as the 6V6, 6BW6, etc., fall comfortably within this category. The circuit of Fig. 1 is fully practical and can be employed as it stands.

The load, which may be imposed on the secondary of the transformer of Fig. 1, can consist of the heater, or heaters, of any valve or valves whose total current consumption is 0.3 amp or less at 6.3 volts. Thus, a single valve comsuming 0.3 amp at 6.3 volts (such as the 6F5), could be driven by the transformer; or either one or two valves consuming 0.15 amp at 6.3 volts (such as the 6BR7), could be similarly driven. Assuming a fixed h.t. potential, the regulation of the circuit is such that the secondary voltage remains sensibly constant for current consumptions from 0.1 to 0.3 amp. Also, due to the fact that the output heater voltage is supplied at a low impedance, values of capacity up to 0.01μF may be connected across the secondary without altering the heater voltage obtained. There would normally, of course, be no necessity to connect a condenser across the secondary, but this point is of importance as it ensures that no losses would be given by feeding the secondary voltage through screened cable, with its attendant capacities, should this be desired.

The efficiency of the circuit of Fig. 1 is surprisingly high. At an h.t. voltage of 240, and employing a 6V6 to drive the transformer, the total anode and screen grid current of the oscillator is only 14 mA for a secondary current of 0.15 amp, and 16 mA for a secondary current of 0.3 amp. Thus the additional h.t. loading presented by the oscillator to a conventional amplifier power pack is small. Also, the additional heater loading of the oscillator valve on the mains transformer would normally be only slightly

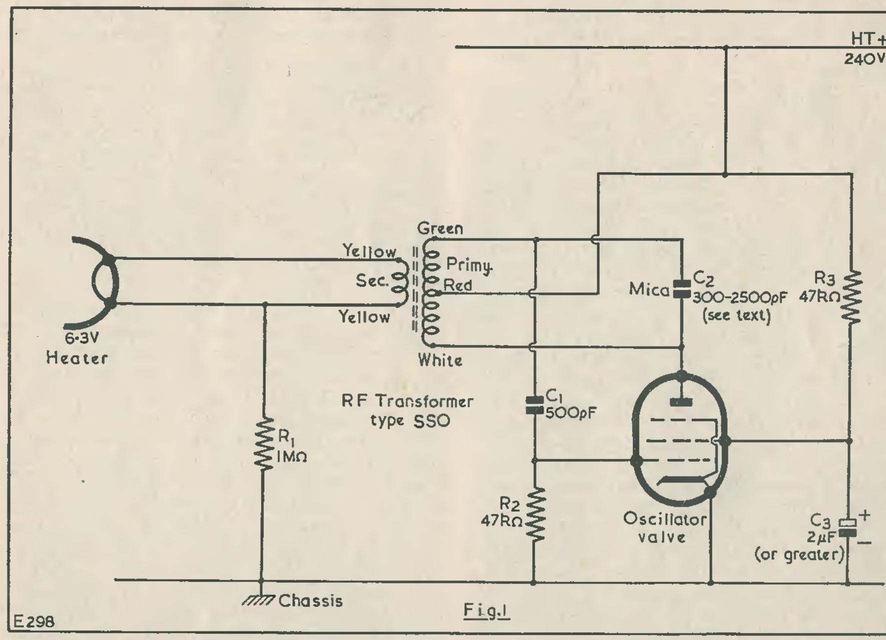


Fig.1

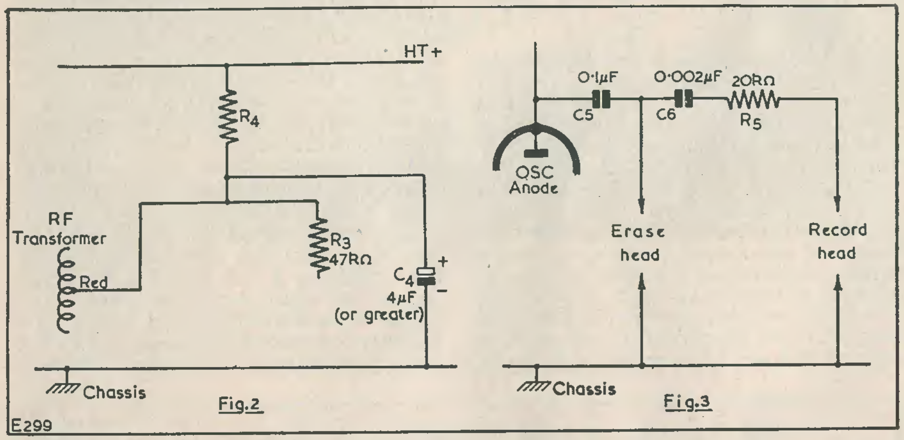
greater than that of the valve heated by r.f., which is not now connected to the mains transformer at all.

The arrangement shown in Fig. 1 does not, incidentally, incur the use of close tolerance components; 20% resistors and condensers are perfectly adequate. In experiments carried out by the writer, empirical component variations confirmed this point.

transformer is connected to the heater of the valve it is eventually intended to drive. The correct dropping resistor will be that which causes approximately 240 volts to appear across the decoupling condenser, C_4, under these conditions.

Tape Recorder Applications

The inductance of the transformer primary is set to a standard by the manufacturer



Regulation

The regulation of the secondary voltage of the transformer depends mainly upon the regulation of the h.t. supply connected to the oscillator valve. In Fig. 1, the peak voltage of the r.f. appearing between the h.t. tap into the transformer primary and the anode of the oscillator tends to approach the h.t. voltage itself. In consequence, the secondary voltage of the transformer is directly proportional to that of the h.t. supply over a large range of values on either side of 6.3 volts. The transformer is designed to operate with an h.t. voltage of 240, whereupon the output voltage is at the rated 6.3. H.T. voltages of 228 and 252 correspond to secondary voltages of approximately 6.0 and 6.6 respectively. No great demands, therefore, are made upon the regulation of the h.t. supply. Due to the simple relationship existing between h.t. and heater voltages, there is the additional incidental factor that it is possible to obtain a measure of the secondary r.f. voltage by reading the h.t. voltage applied to the oscillator. Without this facility it might be difficult to measure the secondary voltage with conventional instruments.

In cases where the available h.t. voltage is too high, the simple dropping and decoupling circuit of Fig. 2 may be employed. When this arrangement is used it would be advisable to find the value of the dropping resistor, R_4, experimentally whilst the secondary of the

before it leaves the factory. In consequence the frequency of operation can be selected within quite fine limits by varying the value of C_2 in Fig. 1. The output of the transformer remains constant for changes in C_2 between the limits 300 pF to 0.0025 μF. However, it is anticipated that the value of C_2 will normally be made either 0.001 or 0.002 μF, or a value in between. At 0.001μF the frequency of oscillation is 54 kc/s, and at 0.002μF 41 kc/s.

It will be noted that these frequencies are those normally employed in tape recording for erase and bias voltages. In consequence, it is possible to employ the transformer not only to heat the first valve of the amplifier but also to provide erase and bias facilities. A suitable circuit for high impedance tape heads is illustrated in Fig. 3. The primary of the transformer in this circuit functions as a high-grade erase and bias oscillator coil and, as the writer has checked experimentally, functions equally well whether the secondary is loaded by a valve heater or not. Indeed, as it stands the transformer is attractive for the oscillator purpose alone; whilst yet another application could be the use of the secondary to light a pilot lamp or heat a Magic Eye recording level indicator. The illumination of either of these would then indicate that the erase and bias oscillator was functioning correctly when the amplifier was switched to the "Record" position.

IN YOUR WORKSHOP

This month J.R.D. takes a back seat and, as an experiment, hands over to Old Smithy, the Serviceman

OLD SMITHY WAS HUMMING AWAY QUIETLY to himself as he proceeded with the task on his bench. He was working on a small, inexpensive, broadcast receiver and he gave a grunt of satisfaction as he adjusted the cores of the i.f. transformers.

At that point the door opened and a young man walked in.

"Hallo, Smithy," he said cheerfully, "anything interesting turned up to-day?"

"Well, fairly interesting," replied Smithy, "but rather routine, I'm afraid. Now look, Dick, since you're just starting up in radio I'll pass on a little problem to you for practice."

Dick walked up to the bench and looked at the chassis which Smithy was holding.

"The trouble with this set," continued Smithy, "is that it has poor selectivity and sensitivity. I'll tell you the rest of the story up to the present moment. When it arrived in the workshop I connected it up to the bench mains and hitched it on to an aerial. The local station came in as loud as one would expect from a set of this type, but it covered rather more of the tuning scale than it should have done. Also, there were hardly any other stations to be heard at all.

"Now whenever I get poor selectivity and sensitivity—especially the former—on this type of set, the first things I examine are the i.f. transformers. Normally, a four-plus-one such as this has a pretty sharp i.f. response. In this receiver the reasonably sharp tuning you expect on the medium-wave band was absent. All this pointed to one or more of the i.f. tuned circuits being faulty, and that is just what I have been checking."

"How did you do that?" asked Dick. "The correct way is to adjust the signal generator to the i.f. of the set, connect its output between the signal grid of the frequency-changer and chassis, and check the i.f. trimming, isn't it?"

"That's true," replied Smithy, "only in this case I 'cheated' a little. The wiring around the frequency-changer valveholder was very crowded so, to avoid short-circuits with the signal generator clip and, incidentally, to save time, I connected the generator output between chassis and the aerial terminal. With the set switched to the long-wave band, preferably off a station, the output of the signal generator soon finds its way to the frequency-changer grid in this class of receiver.

"I next turned the volume control to maximum, attenuated the signal generator output so that its modulation was just audible, and checked the adjustment of the i.f. cores. Adjusting the top core of the first i.f. transformer had no effect, and it was just at that moment that you walked in. Whilst I've been talking I've checked that the core is not broken or mechanically faulty, so I think it would be worth our while to have a look at the transformer itself."

Whereupon Smithy unsoldered the leads of the transformer and removed it from the chassis. He took the can off the coil assembly and examined the windings. Finally, he passed it over to Dick.

"Here you are," he said, "see if you can spot the trouble."

Dick took the transformer and examined it carefully.

"Well, all the litz strands seem to be soldered O.K.", he commented, "although I had better check the winding resistance to make certain. Ah, now here's something; the bottom winding has a resistance of six ohms and the top winding only four ohms. Could that be the cause of the trouble?"

"False alarm!" chuckled Smithy. "If you look at the parallel condensers you'll see that the one across the top coil is 200pF, whilst that across the bottom coil is only 150pF. So the top coil must obviously have fewer turns to make it tune to the same frequency. Incidentally, it's quite common practice for the coils to have different parallel capacities in the first i.f. transformer of a broadcast receiver; the primary winding having the larger capacity. In this transformer the top coil is the primary. No, I think it's quite safe to say that the windings in this transformer are O.K."

"In which case," replied Dick, "all that's left is the condenser across the primary. It can't be short-circuited or we would have obtained a zero ohms reading when we measured the winding resistance. But it could be open-circuit or leaky, couldn't it?"

"Correct," said Smithy, "so let's check it."

He unsoldered the condenser and checked it on the capacity bridge. It was open-circuit.

"Well, that's that problem solved," said Smithy. "We were lucky, too, because these open-circuit condensers are often intermittent. Occasionally, the mere business of unsoldering them shifts their internal connections so that, when you check them, they show correct capacity. However, that's just one of the many little things which are sent to try service engineers! Now the faulty condenser had a value of 200pF2±%. I'll have a look through my stock of 200pF mica condensers to see if I can find a replacement which falls within that range on the bridge."

Whilst Smithy was checking his stock of condensers, Dick examined the i.f. transformer.

"You know, Smithy," he said suddenly, "we all of us accept coils in radio as being part and parcel of the job, yet we rarely consider what goes into their manufacture. Are coils difficult to make?"

Smithy chuckled. "Some are," he replied, "and some aren't. In most cases it is possible to wind coils just by putting the formers on a machine, setting it up, and switching on the motor."

"What about the type of wire that's used," asked Dick. "Does that influence coil design?"

"Well, coil design and coil winding are not quite the same thing," explained Smithy, "although a good coil design must obviously be one that can be wound cheaply and reliably. The question of wire is almost a subject on its own. Most wave-wound coils employ a fabric-covered enamelled wire, such as cotton-, rayon-, or silk-covered enamelled wire. Just for interest I'll give you an instance of the types of ordinary and enamelled wires available on the market to-day.

"First of all," he continued, "there are the copper wires themselves. As you know, of course, these are drawn in various diameters and we measure them in this country by employing the Standard Wire Gauge. Thus, a wire with a diameter of 0.064 inches is equivalent to 16 s.w.g., and so on. When we use stranded wire we use a code whose first figure gives the number of strands and whose second number tells us the gauge of the individual strands. As an example, a piece of flex which employed 7/36 s.w.g. wire would consist of 7 strands of 36 s.w.g. wire. The same code applies to litz wire, although in this case the strands are insulated from each other, of course. Sometimes, manufacturers use the wire diameter in inches rather than its s.w.g. number, whereupon you may get a piece of stranded wire identified as 9/0.018. That's a wire with 9 strands of 0.018 inch, or 26 s.w.g. wire."

"How do you remember those wire diameters?" asked Dick, impressed.

"It's easy," said Smithy modestly, surreptitiously sliding the wire gauge table on his bench out of sight. "After you've handled them for a while you learn the more common wires off by heart.

"Then," he continued, "you have the wire enamels. At the present moment there are three main types of enamel. These are the oil-based enamels, the synthetic enamels, and the 'solder-through' or 'self-soldering' enamels.

"Of the three, the oil-based enamels are the cheapest available, and manufacturers obviously try to use them wherever possible. Unfortunately, oil-based enamels cannot stand up to very harsh treatment—that is to say, their 'abrasion resistance' is low—and they are easily dissolved by some of the solvents used in impregnating dopes. Nevertheless, they are satisfactory for most normal varnish or wax impregnating, so they can be used in mains transformers, smoothing chokes, speaker transformers, and similar components. Incidentally, carbon tet. and trichlorethylene will dissolve some of the oil-based enamels, so you want to keep these cleaning fluids well clear of transformers and chokes if you use them in servicing.

COPPER WIRE DATA

Standard Wire Gauge	BARE COPPER WIRE: Diam. in inches	BARE COPPER WIRE: Approx. safe current	BARE COPPER WIRE: Length per ohm	BARE COPPER WIRE: Weight per 1000 yds	ENAMELLED Oil-based 'N': Turns per in approx.	ENAMELLED Oil-based 'N': Yards per lb or oz	S.C.C.: Turns per in approx.	S.C.C.: Yards per lb	D.C.C.: Turns per in approx.	D.C.C.: Yards per lb	S.S.C.: Turns per in approx.	S.S.C.: Yards per lb or oz	D.S.C.: Turns per in approx.	D.S.C.: Yards per lb or oz
		amps.*	yds	lb		lb		lb		lb		lb		lb
10	·128	12·9	535	148·8	—	—	7·35	—	7·04	—	7·64	—	7·55	—
12	·104	8·5	353	98·2	9·26	—	8·93	—	8·47	—	9·35	—	9·22	—
14	·08	5·0	208	58·1	11·9	—	11·4	—	10·6	—	12·1	—	11·8	—
16	·064	3·2	135	37·2	14·8	26·4	14·1	26·1	13·2	25·6	15	26·4	14·7	26·1
18	·048	1·8	53·4	20·9	19·7	46·9	18·3	46·3	16·9	45·4	20	46·8	19·6	46·3
20	·036	1·0	42·4	11·8	26·1	83·3	24·1	81·7	21·3	79·2	26·3	85·3	25·6	82·5
22	·028	·61	25·6	7·12	33·3	137	29·8	134	25·6	129	33·3	137	32·2	134
24	·022	·38	15·8	4·4	42·1	221	37·0	219	31·2	203	42·1	222	40·0	218
26	·018	·25	10·6	2·94	50·6	330	43·5	311	35·7	294	50·6	332	48·8	325
28	·0148	·17	7·18	1·99	61·4	488	50·5	452	40·2	422	60·4	488	57·8	478
30	·0124	·12	5·03	1·40	73·3	694	57·5	634	44·7	587	72	695	67·1	675
32	·0108	·09	3·82	1·06	83	915	63·3	835	50·5	755	81·3	912	75·2	887
34	·0092	·07	2·77	·77	98	1,202	70·5	1,280	54·9	1,024	93·4	1,250	85·5	1,220
36	·0076	·05	1·89	·52	116	1,840	86·2	1,610	64·1	1,477	110	1,815	99·0	1,730
38	·006	·03	1·18	·33	143	2,810	100	2,550	71·4	2,287	133	2,871	117	2,760
		mA	in	oz		oz						oz		oz
40	·0048	18	27·15	3·35	180	286	112·5	3,910	78·1	3,456	159	276	137	258
42	·0040	12·6	18·87	2·32	217	411	—	—	—	—	192	387	161	358
44	·0032	8·0	10·77	1·49	270	642	—	—	—	—	227	599	185	536
45	·0028	6·0	9·24	1·14	303	835	—	—	—	—	250	752	200	675
46	·0024	4·5	6·78	·83	357	1,128	—	—	—	—	278	1,000	217	871
47	·0020	3·1	4·71	·58	—	1,630	—	—	—	—	312	1,375	238	1,190
48	·0016	2·0	3·02	·37	—	—	—	—	—	—	—	—	—	—
49	·0012	1·1	1·70	·21	—	—	—	—	—	—	—	—	—	—

*At 1,000 amps. per sq. in.

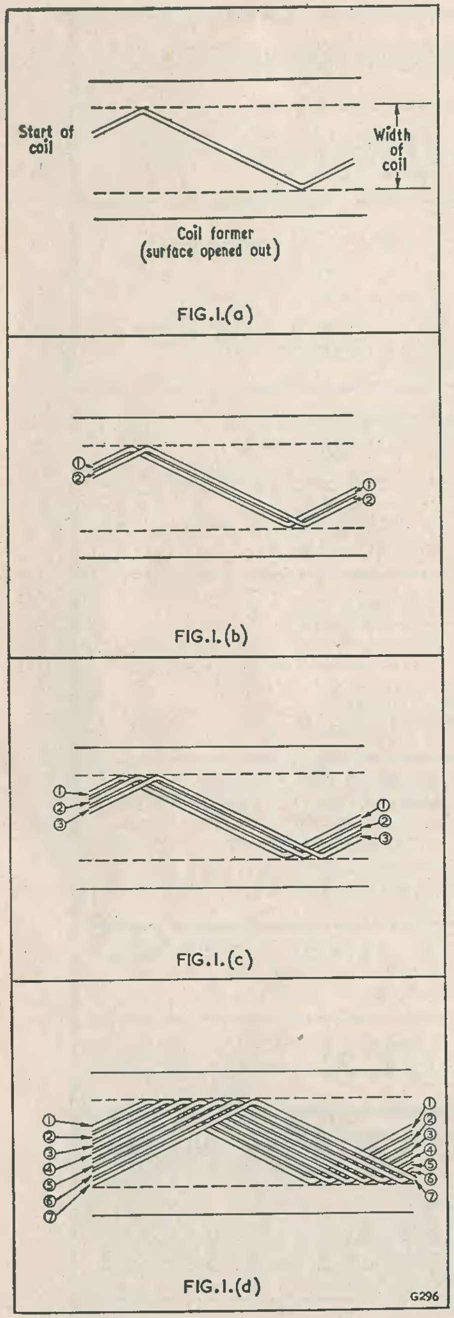


Fig. 1. Successive steps in the winding of a wave-wound coil.

"The synthetic enamels are tougher than the oil-based enamels and do not dissolve so readily when certain dopes or varnishes are applied to them. For this reason they are ideal for wave-winding, and certain r.f. coils. As they have a high abrasion resistance they do not fracture so easily during winding, with the result that a synthetic enamelled wire is ideal for such things as deflector coils, where high pulse voltages are liable to appear between turns. If breaks in the enamel due to low abrasion resistance occurred during the winding of coils of this type, breakdowns between turns could occur.

"Finally, there are the 'solder-through' enamels. These are practically as tough as the synthetic enamels, and they have practically the same solvent-resisting properties. Plus, of course, the great advantage that the enamel can be made to melt at soldering temperatures, thus saving the trouble of stripping the enamel before soldering."

"Can you melt 'solder-through' enamel with an ordinary soldering iron?" asked Dick.

"With most 'solder-through' enamels—no," replied Smithy, "but an iron with a slightly raised bit temperature should cope satisfactorily in most cases."

"Well," said Dick, "I didn't think a piece of enamelled wire could be so complicated!"

"We've only just touched upon the surface," said Smithy. "There's the question of enamel thickness as well. For instance, the enamel on a wire can be either fine, medium, or thick as desired, this being shown by the letters 'F,' 'M,' or 'T.' However, that doesn't apply to oil-based enamels. The thickness of these enamels is either 'normal' or 'thick.' The idea behind the various thicknesses is that of providing insulation. You wouldn't normally use an 'F' wire on a coil if there was liable to be a high voltage between turns. The enamel insulation might break down. But an r.f. tuning coil in a receiver would be perfectly O.K. if wound with 'F' enamelled wire, due to the negligible voltage existing between turns."

Dick had returned to examining the windings on the i.f. transformer Smithy had removed from the set.

"Tell me," he asked, "how do they get the winding effect where the wires cross each other so neatly? Is this what you meant just now by a wave-winding?"

"Ah, yes," said Smithy. "That's the correct term. Wave-winding is a special type of winding which enables the coil to be self-supporting without cheeks. There are other advantages to wave-winding as well. For instance, with a wave-winding you can produce coils one after the other whose inductance and self-capacity are almost identical with the prototype."

"I see. Does the wire have to be placed on the former in a certain way?"

"Well," said Smithy, taking up a piece of paper and a pencil, "it's like this. Let us assume that we want to wave-wind a coil. We commence by laying the wire on the former such that it starts from one side of the coil, carries on over to the other side, and then comes back again. Like this (Fig. 1 (*a*)). In this sketch, I've assumed that the surface of the coil former has been opened out so that it is in a flat plane.

"Right! Having put the first turn on we start on the second turn. Only this time we arrange it so that, while it still travels from side to side of the coil, it is either very slightly in front of the first turn, or slightly behind it. See the effect? (Fig. 1 (*b*)). The two wires are touching each other all along their length and are lying side by side on the surface of the former. In this case the second turn is in front of the first turn. We then wind on the third turn (Fig. 1 (*c*)). This, once more, is just slightly in front of the previous turn. Next, we carry on to the fourth, fifth and sixth turns, and so on (Fig. 1 (*d*)). Each successive turn crosses over from one side of the former to the other. Can you see how the coil is now beginning to 'build up'? For the record, a winding in which each successive turn lies behind the previous turn is called a 'progressive' winding, and a winding in which each successive turn lies in front of the previous turn is called a 'retrogressive' winding. These adjectives sound rather Irish, I know, but when you consider the whole process in terms of coil rotation and wire guide cycles they make good sense. Most coils these days use retrogressive windings, but, so far as I know, there isn't much to choose between the two types."

"Well," said Dick after a ruminative pause, "it just goes to show that whenever you look into something in radio which you've previously taken for granted you find a whole field of knowledge which you never even thought existed."

"That's very true," commented Smithy. "In the radio game you just never stop learning. Anyway, I think that that's a long enough session for now. Besides, I've got a living to earn! I've found a 200pF mica condenser which falls nicely into the tolerance we required just now, so we'd better think of getting the i.f. transformer for this set fixed up. After which we might have a look at that t.v. in the corner there. It has no frame sync and I've promised it by to-night. . . ."

Smithy will be returning next month to give further details of the manufacture of wave-wound coils.

New G.E.C. Valve for Television Receivers

Improved Performance with W729

With the advent of multi-channel reception, modern television receivers often have to handle signals of widely differing amplitude from different stations. In some localities the receivers have to deal with strong signals, and with conventional i.f. amplifier valves and automatic gain control circuits cross modulation between vision and sound signals often results. This is most noticeable as an objectionable buzz superimposed on the sound output.

Conventional variable mu valves do not produce cross modulation distortion but they have generally poor control characteristics which render them unsuitable for use in television i.f. amplifiers.

The General Electric Co. Ltd. has therefore introduced a new Osram valve, the W729, which is scientifically designed to minimise cross modulation distortion while still maintaining good control characteristics and a high maximum slope. The W729 is being incorporated in future designs of G.E.C. television receivers.

Mullard Films and Lectures

Mullard film meetings are held for the trade throughout the country, but readers may not know that the activities of the films and lectures organisation extends beyond this.

Members of amateur radio societies are also catered for, and many have already had the opportunity of attending these meetings or borrowing Mullard films for their own meetings.

It may be that those readers who are secretaries of such societies, and who have not heard of these activities, would like to avail themselves of the facilities available. The Films and Lectures Organisation, Mullard Ltd., Century House, London, W.C.2 will be pleased to send them full details.

BAND III TELEVISION for the HOME CONSTRUCTOR

PART 10. *by* **S. WELBURN**

This month our contributor, S. Welburn, surveys the existing television scene in America before carrying on to aerial matching and oscillator frequency drift. He finishes by describing the process of adding a capacitive fine tuner to a converter not already so fitted

WHILST WE IN GREAT BRITAIN ARE JUST commencing to use Band III for television transmissions, the situation in America has been such that both the v.h.f. and u.h.f. bands (approximately equal to our Band III and Band IV respectively) have been employed by T.V. stations for several years. Because of this fact it would be interesting and instructive to examine the conditions existing in the States at the present time. The writer would like to add that he is indebted to our American contemporary *Radio-Electronics* for the information given here.*

The American Scene

Put briefly, the situation in America is that, whilst v.h.f. television transmitters constitute profitable business enterprises, most u.h.f. stations do not. Of the 100-odd u.h.f. transmitters on the air a recent F.C.C. investigation has revealed that only 18 were operating at a consistent profit, most of these being in areas without v.h.f. competition.

The main reason for this state of affairs is given by the proportionately low-area coverage of a u.h.f. transmitter when compared with that of a v.h.f. station. In addition, the public has shown a distaste for u.h.f. converters and their extra installation charges. The result of these two factors has been that u.h.f. transmissions have not entered sufficient homes to enable a profitable revenue from advertisers to be obtained.

Whether such a situation would occur in the U.K. is difficult to prophesy. Our population is contained within a relatively small area, and u.h.f. transmissions should consequently be capable of being received by proportionately large numbers of people. A u.h.f. transmitter situated in London or Birmingham would, for instance, provide quite an adequate service for most of the people living in either of these cities, as well as a possible number outside. The question of consumer resistance to u.h.f. converters is a point which has also to be considered, although it has to be remembered that no great opposition to Band III converters seems to be apparent at the present time. It seems unlikely, therefore, that if we in Great Britain were to decide to employ u.h.f. bands for television transmissions we would bump into as many snags as have been encountered in the U.S.A.

Incidentally, the writer would like to add that his interest in u.h.f. is occasioned not only by the fact that Band IV might be used for future television transmissions owing to the almost inevitable filling up of Band III; but also because of an unconfirmed rumour that there is a possibility of our having a higher definition standard at some future date. What truth there is in this rumour the writer would hesitate to state, but if higher definition transmissions *do* make their appearance their increased band width could quite conceivably result in a shift to Band IV.

Illegal Transmitters

Another most interesting fact discussed in the *Radio-Electronics* article mentioned above is concerned with the operation of illegal television transmitters. In some parts of North-West America there are a number of remote communities whose television reception is cut off by neighbouring hilly country. To overcome their loss of signal, quite a few towns have erected receiving stations on the "live" side of the hills, the received signals being then re-transmitted by "boosters" directed onto the community. These boosters have very low power output—frequently less than a watt—and employ quite simple aerial arrays. The stations operate entirely unmanned.

Such transmitters are unlicensed and are quite illegal. Nevertheless, they serve an extremely useful purpose. As a result there is now an active political drive to try to legalise these small transmitters. The F.C.C. opposes this, arguing that it cannot license booster stations owing to the fact that, amongst other things, they do not conform to the high engineering standards required of television stations.

Channel 10

In Great Britain, Channel 10 has now been announced as the third I.T.A. channel, and interest in Band III receives yet a further fillip. The fourth I.T.A. channel will probably be Channel 7, and should be announced later on this year. Readers who reside in the new Channel 10 area will now be able to lay their plans for alternative T.V. with plenty of time to spare. No doubt the Belling-Lee temporary transmitter will be well to the fore once more, again providing test signals before the commencement of permanent I.T.A. transmissions. Belling-Lee deserve very warm praise for the go-ahead manner in which they have already helped the industry in making available these test transmissions.

Readers who have followed this series of articles will, of course, be aware that all the home-constructor converters which have been described therein are just as suitable for Channel 10 as they are for Channels 9 and 8.

Aerial Input Impedances

Although 75 ohm impedance cable is nearly always that employed in this country for aerial downleads, it seems that there are quite a few experimenters who wish to employ 300 ohm aerial feeder cable, or who wish to use receivers having 300 ohm input circuits. The difficulties of matching together circuits of 75 and 300 ohm impedance then become apparent.

Fig. 1 (a) shows the input circuit of a television receiver which is intended to operate both with 75 ohm and 300 ohm inputs. The aerial coupling coil consists of a centre-tapped winding, the two equal halves being $L_{1(a)}$ and $L_{1(b)}$. With a circuit of this nature it is possible to connect a 75 ohm aerial cable to either $L_{1(a)}$ or $L_{1(b)}$, or a 300 ohm feeder across the two outer points of the coil. Fig. 1 (b) shows the various combinations. It will be noticed that, in each case, a correct termination is obtained. Thus, when the

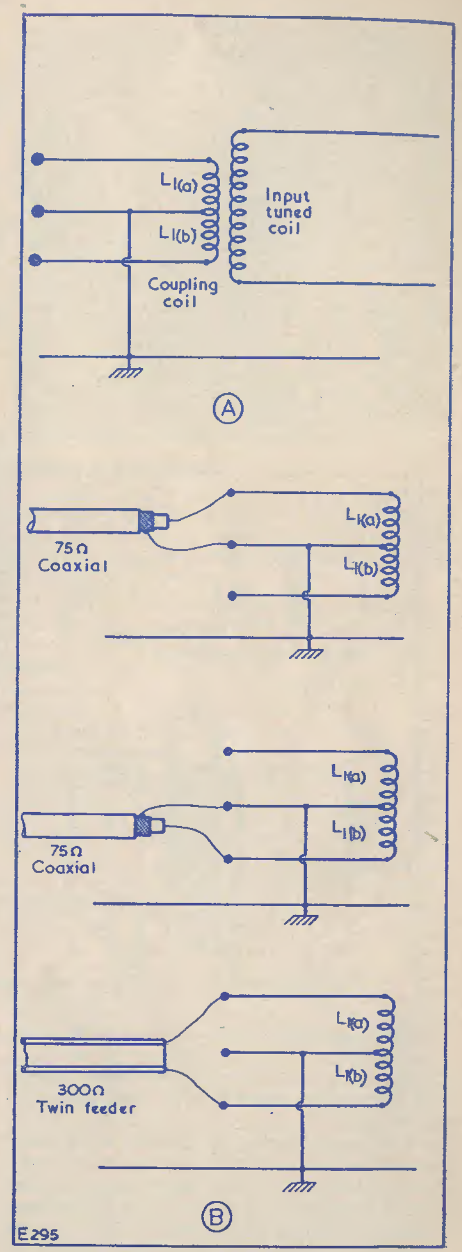


Fig. 1 (a). A television input circuit capable of accepting both 75 and 300 ohm aerial input impedances. Fig. 1 (b). Showing the various ways in which different aerial input impedances may be connected to the circuit of Fig. 1 (a).

* "1956—Television's Year of Design" by David Lachenbruch;—*Radio-Electronics;* Jan. 1956.

75 ohm unbalanced cable is connected to $L_{1(a)}$ or $L_{1(b)}$ its outer conductor is connected to the chassis, which is just what is required. At the same time, when the 300 ohm balanced cable is connected to the coil its two conductors are balanced about earth, this being also the desired condition. It should be pointed out that, although the number of turns on the complete coupling coil is only twice that of either half, the impedance presented by the complete coil is four times that presented by each half. A circuit such as that shown in Fig. 1 (a) could, quite feasibly, be fitted into the input stage of a televisor designed both for 75 ohm and 300 ohm inputs. It is used, in point of fact, in the Valradio Tuner Unit intended for the conversion of the Magnaview.† Fig. 1 helps to illustrate very clearly the technique required introducing too high a self capacity. A suitable arrangement is shown theoretically in Fig. 2 (b), and in practical form in Fig. 2 (c). In these two diagrams a bifilar winding is employed, the turns being spaced from each other to keep the self capacity down. The former employed in Fig. 2 (c) could consist of any reasonably low-loss material having a diameter of approximately ¼-inch, and the wire could consist of 16 to 22 s.w.g. enamelled copper. The whole assembly should be screened in a can whose inside wall does not approach the winding by less than ⅜-inch, and which is connected to the outer conductor of the coaxial cable and the earth terminal of the receiver. All leads should be kept as short as possible. The impedance-matching coil should function satisfactorily both at Band I and Band III.

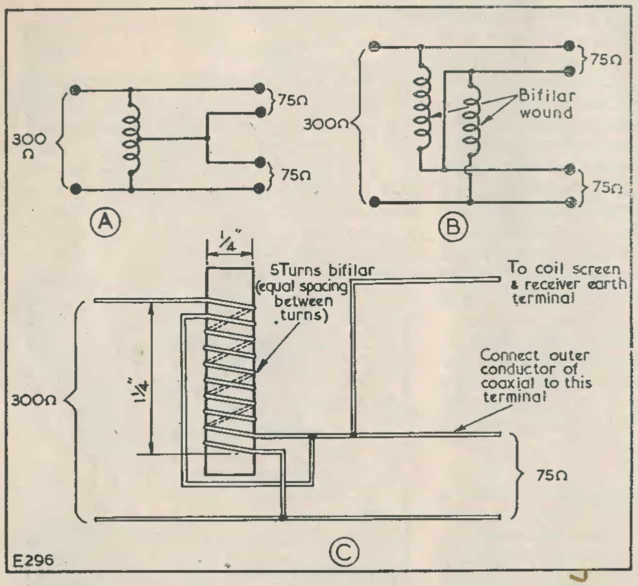


Fig. 2 (a). A simple impedance-matching coil. Fig. 2 (b) For best results the impedance-matching coil should employ a bifilar winding. Only one 75 ohm outlet would be needed in practice. Fig. 2 (c). A practical impedance-matching coil. Further details are given in the text

for matching together 75 and 300 ohm circuits.

For those wishing to connect a 300 ohm aerial feeder to a 75 ohm input circuit, or vice versa, the circuit of an impedance-matching coil is illustrated in Fig. 2 (a). As will be seen, the coil consists quite simply of a centre-tapped winding, the 300 ohm impedance being the centre and either end.

For good results, in practice, it would be important to ensure that the two halves of the coil shown in Fig. 2 (a) were as tightly coupled together as was possible without

† *Radio Constructor*, July/August, 1955.

Band III Ghost

Whilst on the subject of aerial impedances, the writer would like to report, in passing, a case he recently encountered in which a faint ghost appeared on Band III. The trouble was apparently due to a slight mismatch into the aerial coil of the receiver, and it was cured by inserting at the input socket a 6 dB resistive attenuator between the Band III aerial coaxial lead and the receiver. After the attenuator had been fitted the aerial down-lead was then terminated by an impedance which more closely resembled 75 ohms, thus reducing the standing wave ratio in the down-

lead. The mismatch between the attenuator and the receiver input coil was relatively unimportant. Fortunately, there was sufficient signal pick-up in the locality to allow the loss of 6 dB of signal strength to be sustained; and the all-important signal/interference strength ratio remained unaltered.

Frequency Drift

The problem of oscillator frequency drift in Band III converters does not appear to have proved as troublesome as some engineers predicted before the commencement of the new television service. This may possibly be due to the fact that the sound and vision i.f. strips of most televisors are sufficiently broad in response to allow a considerable amount of drift to occur before the resultant degradation in picture quality is noticed by the average lay viewer.

So far as the amateur who is building his own converter is concerned, excessive frequency drift can usually be avoided by careful choice of the components he uses in the oscillator circuit. A good policy consists of employing a ceramic valveholder for the frequency-changer oscillator, together with good quality ceramic condensers in the oscillator tuned circuit. Most ceramic condensers have a slight positive drift (i.e. capacity increases with temperature) and can usually be employed quite safely. Mica condensers should never be used in Band III oscillator circuits. Ceramic n.t.c. condensers (that is, condensers marked with a negative temperature coefficient number) are probably best avoided if their coefficient is greater than, say, 330; this being due to the fact that their change in capacity may be too large when their temperature increases. Unfortunately, quite a few n.t.c. condensers on the market are colour-coded, the codes employed being applicable to the particular manufacturer of the condenser only. In consequence, the amateur may use such condensers under the impression that they are low-drift types. However, if a condenser has its value printed on it it is usual for its temperature coefficient, assuming an n.t.c. component, to be similarly marked. N.T.C. condensers can, of course, be employed quite safely in positions where their drift in value will not affect the oscillator frequency.

(The writer would like to point out that the purpose of n.t.c. condensers is, of course, that of reducing oscillator drift. However, the process of selecting a condenser with required coefficient for a particular oscillator circuit usually takes a considerable amount of time. The safest policy for the amateur, therefore, is that of using normal condensers and keeping the oscillator components reasonably cool.)

Having built up an oscillator stage using a ceramic valveholder and ceramic condensers in the tuned circuit, the next step consists of preventing excessive temperature rise. Conventional Band III converters normally dissipate very little heat, with the result that adequate ventilation at once provides a good insurance against drift. This does not apply, however, if the converter is fitted into the same cabinet as the televisor itself. Some television receivers become almost red-hot after several hours of use!

A possible slight reduction in drift could be given also by the use of a black screening can for the oscillator valve instead of one having a shiny surface. The black can would then enable more heat to be radiated away from the valve, and would be of some additional assistance in reducing drift.

Adding a Fine Tuner

A most useful accessory to any Band III converter not already so fitted is a fine tuning control. This is of value in enabling short- and long-term drifts in oscillator frequency to be tuned out.

With most converters the process of fitting a fine tuning control is quite simple. Indeed, the problem is usually more of a mechanical than an electrical nature. All that is required is the mounting of a small low-capacity tuning condenser close to the oscillator coil, a means being provided—say, by an extension spindle—to control the condenser from the panel or case of the converter. The layout of some converters may be such that the tuning condenser can be mounted directly on the case.

The tuning condenser employed as a fine tuner should be a miniature component having a maximum capacity of approximately 5 to 10 pF. A condenser of this value should then be capable of providing some 2 to 6 Mc/s swing in oscillator frequency. A slow-motion drive will not be necessary, the tuning knob being coupled directly to the condenser spindle. The insulating material used in the construction of the condenser should either be ceramic or have similar low-loss properties. Miniature tuning condensers of the type required here can often be found in surplus equipment, or may be available new. In cases where the tuning condenser chosen has too high a capacity, this can be reduced by removing one or more vanes until the capacity is correct. However, when such a procedure is adopted it is advisable to "prune" the condenser *after* it has been mounted in the converter, reducing capacity until the requisite tuning range has been obtained. This process ensures that the condenser will function correctly in the particular converter in which it is to be used. (Fine tuning condensers of equal capacity

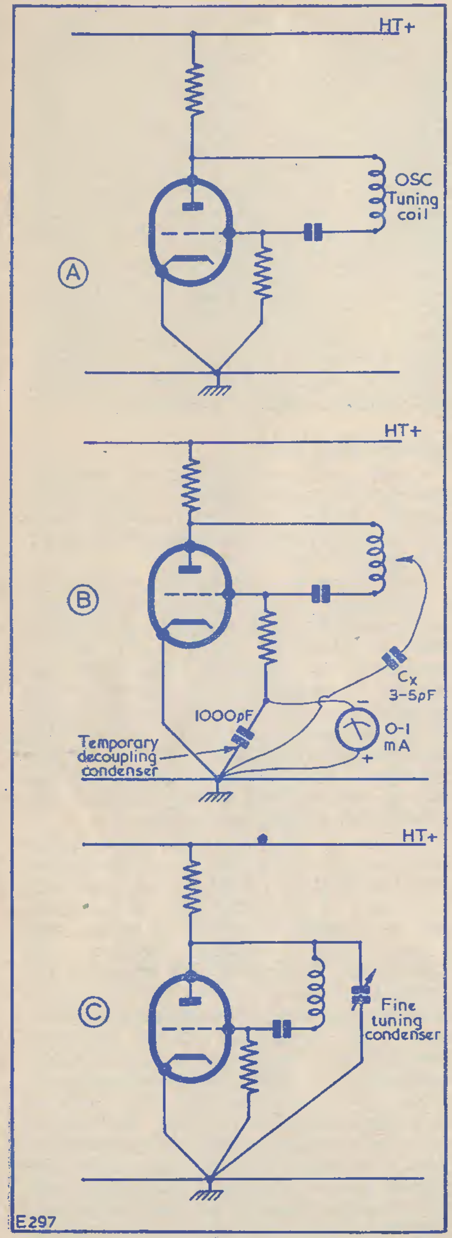


Fig. 3 (a). The basic Colpitts oscillator circuit employed in almost all Band III converters. Fig. 3 (b). A test circuit for determining to which end of the oscillator coil a fine tuning condenser should be connected. Fig. 3 (c). A fine tuner in circuit

will not necessarily give equal tuning range in converters of different manufacture, owing to design variations in the fixed tuning capacities.)

Almost all Band III converters employ a Colpitts oscillator circuit of the type shown in Fig. 3 (a). The additional fine tuner is then connected between one end of the oscillator coil and the chassis earth tag employed by the oscillator valve. Connecting up the tuning condenser will slightly unbalance the ratio of the capacitive tap into the tuned coil, and it is necessary to experiment to find to which end of the coil it should be connected for best results.

The test circuitry involved in determining this point is illustrated in Fig. 3 (b). In this diagram a 0–1 milliameter (or multi-testmeter switched to an appropriate current range) is inserted at the earthy end of the oscillator grid leak in order to read grid current. The leads of the meter are decoupled by a 1,000 pF ceramic condenser mounted very close to the valveholder. A fixed ceramic condenser, C_x, of some 3 to 5 pF is next connected between the oscillator chassis tag and either end of the oscillator coil. The end of the coil to which the fine tuner should be connected is then that which, when coupled to chassis via C_x, causes the higher grid current reading to be given in the meter. In many cases it is possible that connecting C_x to one end of the coil will result in a higher grid current reading than is given when the condenser is omitted. In such an instance the balance of the oscillator tuned circuit will be slightly improved by the addition of the fine tuning condenser.

Fig. 3 (c) shows the fine tuning condenser actually in position, and assumes that the anode end of the coil is that which gave the greater grid current reading during the previous test. After fitting the tuning condenser the slug of the oscillator coil will, of course, have to be readjusted in order to cause the required Band III signal to appear at the centre of the fine tuning control's travel.

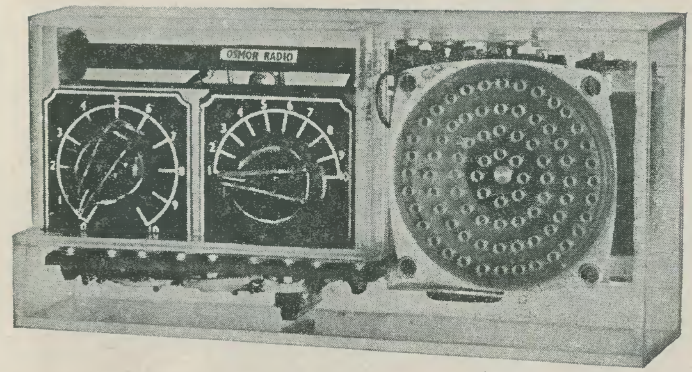
The Mark II Converter

As readers may be aware, probably the most popular home-constructor Band III converter in this country is the Teletron Mark II Unit which was introduced in this magazine last year. Since publication, the writer has been able to judge from field reports the success of this converter; and he would like to give, in particular, the following details provided by a radio and television company in Newark.

A locked picture from the London transmitter was obtained by this company at their Southwell works employing the Mark II converter and a 5-element Antiference

(continued on page 574)

The "TRANSISTORETTE"



PART 3. *by* **G. A. FRENCH**

This article is the third in the series describing this modern transistor receiver, and it deals fully with the wiring and testing of the completed chassis

In last month's article we discussed the various parts which go together to make the chassis of this miniature receiver. We ended by assembling the principal parts and components in readiness for wiring up. We shall now carry on to discuss that process.

Precautions

Before proceeding further, however, it would be very advisable at this stage to reiterate the simple precautions which are necessary when building a miniature receiver employing transistors. Apart from the care which is normally needed when wiring up any miniaturised equipment, especial attention has to be paid in this case to the question of preventing damage to the transistors by overheating. Amongst other things, such overheating can be caused by holding the iron too long against the lead-out wires whilst soldering the transistors into position.

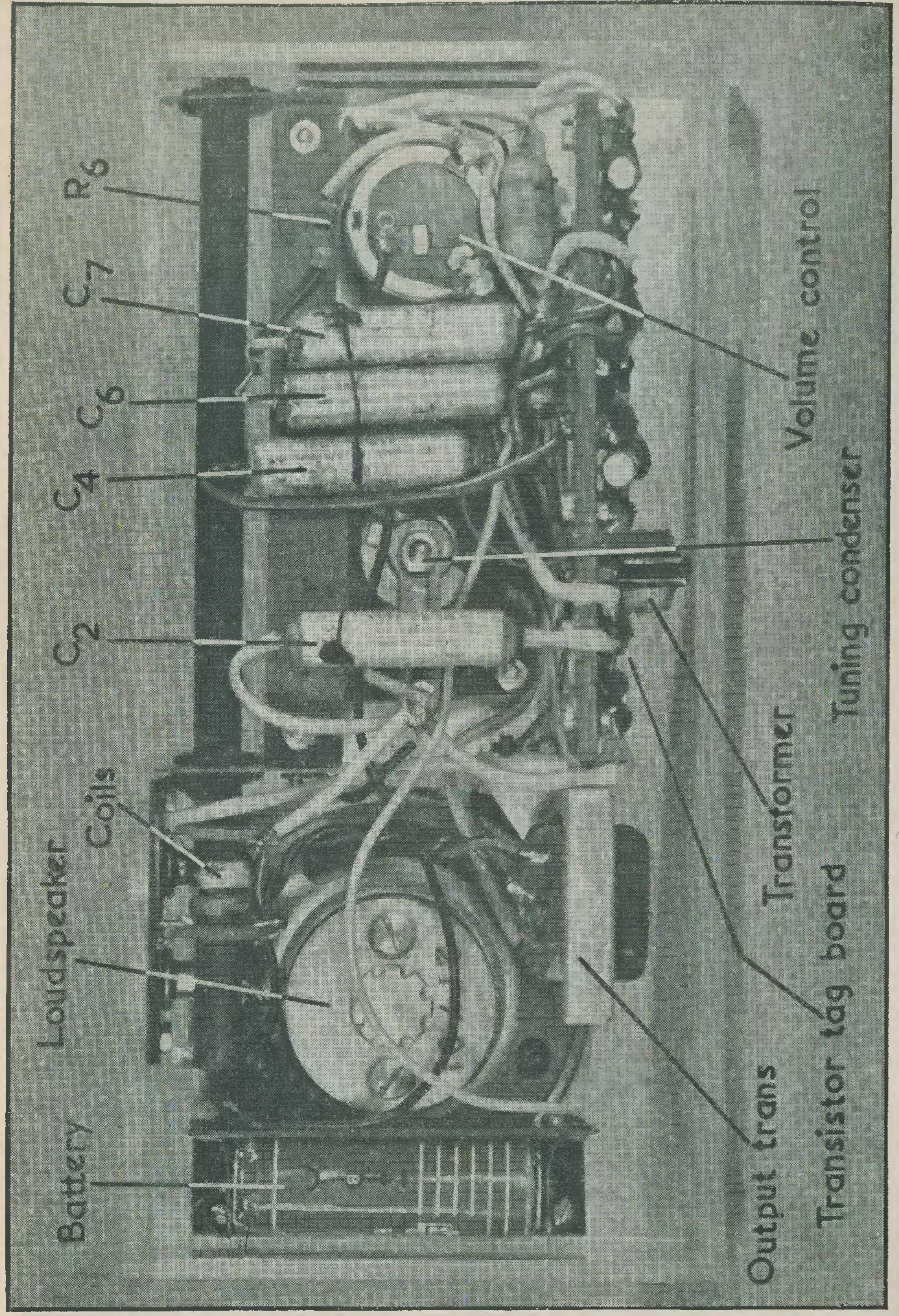
Because of this possible trouble, three precautions are recommended in the present design. Firstly, the transistor lead-out wires are cut some distance away from the body of the transistor, even when this necessitates folding the appropriate lead-out wire back on itself. Secondly, the transistors are the last components to be fitted to the chassis. And, thirdly, they are connected by "laid-on" joints.

These "laid-on" joints are obtained by previously soldering the tag-spills to which the individual transistors are to be connected. The appropriate length of the transistor lead-out wire is next quickly tinned and laid against its tag-spill. A quick application of the soldering iron then causes the solder on the tag-spill to cover the lead-out wire and a quite satisfactory joint results. This joint should be just as good as that given by the more normal method of twisting the appropriate lead around its tag before soldering, and it has the considerable advantage of reducing any possible risk of overheating the transistor. It also enables transistors to be removed from the chassis in a similarly quick manner, should this ever be required.

Wiring

We may now commence with the wiring details proper for this receiver. The first step is illustrated in Fig. 15. To facilitate simplicity of presentation, the resistors and condensers shown in this and succeeding wiring diagrams may not necessarily be drawn exactly to scale.

Fig. 15 shows the view looking at the back of the receiver chassis. The row of 8-BA



View from rear, with main components identified

tag-spills shown are those which are closer to the reader's eye. The other row of tag-spills are not employed in this or any succeeding diagram which gives this view. Note that the miniature deaf-aid transformer is also mounted at this stage, its clamp being secured by two short 6-BA nuts and bolts to the "transformer-mounting holes" of the transistor tag-board. (See Fig. 8 of last month's article.) The transformer is mounted such that its green lead leaves the transformer bobbin on the side shown in Fig. 15. As was mentioned last month, the transformer should be handled with reasonable care in order to avoid damage.

Apart from the three tags connecting to the potentiometer section, there are three further tags on the volume control. Two of these, to the left in Fig. 15, are those of the on-off switch, and the third (designated in Fig. 14 of last month's article) is the earth lug integral with the metal case of the volume control. This point is mentioned in order to stress the importance of connecting the switch circuit correctly. The earth lug on the volume control also supplies the earth connection to the metal parts of the chassis.

R_8 and C_3 in Fig. 15 should be positioned such that they lie below the level of the condenser support strip. This is done to allow room for later components to be fitted. As C_3 has a metal case it is advisable to insulate this in order to prevent its touching adjacent metal parts and, in consequence, giving rise to crackles. Adequate insulation may be given by wrapping thin cellulose tape over the metal part of the condenser or by fitting it with a thin insulating sleeve. This type of condenser may be available from some suppliers, incidentally, already fitted with an insulating sleeve. It must, of course, be connected into circuit with correct polarity. Condenser C_5 is mounted close to the back of the transistor tag-board and has to lie only below the level of the bottom edge of this board. In practice it fits in comfortably between the volume control and the tag-board.

The wiring shown in Fig. 15 is self-explanatory and requires little further discussion. Although not shown, all leads should be insulated with sleeving which must cover the appropriate wires right up to their respective soldered connections. Almost any bare lead, with the consequent risk of short-circuits in the miniaturised layout used here, is inviting future trouble or even possible accidental damage to the transistors. All joints marked "X" in this and successive wiring diagrams should not be soldered, as subsequent leads have to be fitted to the solder tags so designated.

The next stage in the wiring is illustrated in Fig. 16. This stage adds C_2, C_4, C_6, C_7 and R_6. C_6 and C_7 are connected together at their positive ends by means of a twisted joint, R_6 being connected also to this twisted joint. The joint is, of course, subsequently soldered. As C_4, C_6 and C_7 lie very close to each other, crackling may be caused by their metal bodies touching each other. This trouble can be obviated by insulating the body of C_6 in the same manner as was described above for C_3. The four electrolytic condensers should be mounted such that they lie horizontally, their ends resting on the condenser-support strip as illustrated in Fig. 16. In such a position they should then be situated just below the level of the transistor tag-board.

Some of the connecting leads from the four electrolytic condensers pass over the edge of the tag-board to connect with the appropriate tag-spills on the front. These leads should lie close to the edge of the tag-board. The negative lead from C_4 will probably not be sufficiently long to reach the tag-spill shown for it in Fig. 16. If this occurs it may be extended, the consequent joint being adequately covered with sleeving.

Some care will be needed in positioning the four electrolytic condensers, this being due to the fact that excessive strain on their wires may cause damage at the lead-out points. It is possible in consequence that the condenser lead-out points will overhang the condenser support strip. This is unimportant so long as they will not foul the Ferrite rod of the aerial coil when it is later fitted. It must also be pointed out at this stage that the lead-out wires at either end of the electrolytic condensers are anchored to metal plug-like terminals. It is important to ensure that, at the transistor tag-board end of the individual condensers, the sleeving used covers both the lead-out wire *and* these anchoring terminals. Otherwise, short circuits to the 8-BA bolt-heads may occur.

After wiring, the condensers are secured to the condenser-support strip by means of thread. A length of this thread should be looped and its two ends passed through the pair of holes in the support strip which is adjacent to the particular condenser or condensers to be secured. The ends are then brought round the underside of the support strip, up around the body of the condenser and tied securely. C_2 and C_4 are fixed individually in this manner, whilst C_6 and C_7 are secured together. The knots in the thread may afterwards be painted with varnish to prevent their working loose.

The three "fly-leads" shown in Fig. 16 can be from two to three feet long and should employ flexible wire. These leads are used for testing the receiver and will be later cut down for connection to the h.t. battery and speaker transformer when the set is installed in its cabinet. It is very advisable to use red and

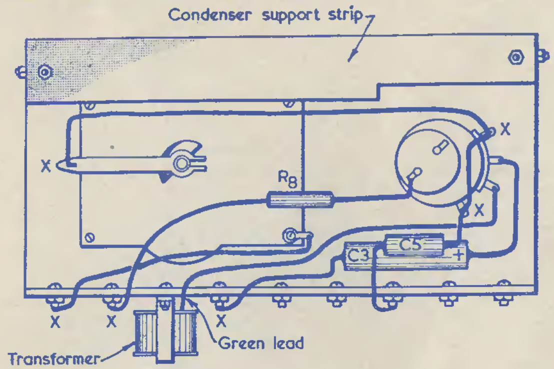


FIG. 15.

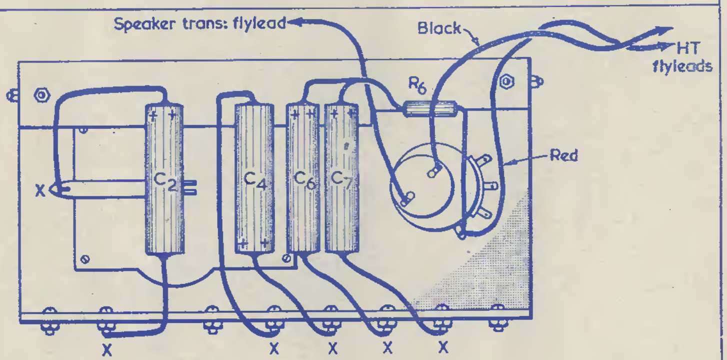


FIG. 16.

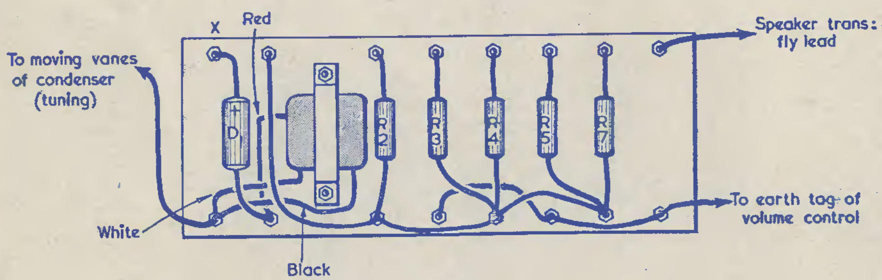


FIG. 17.

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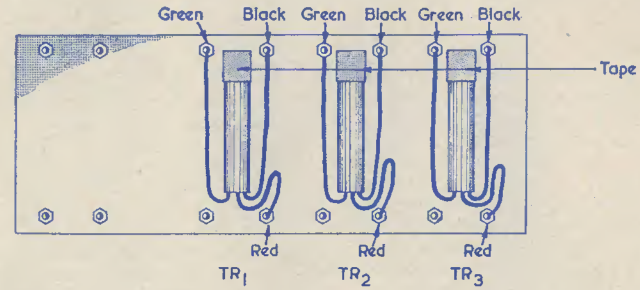

FIG. 18.

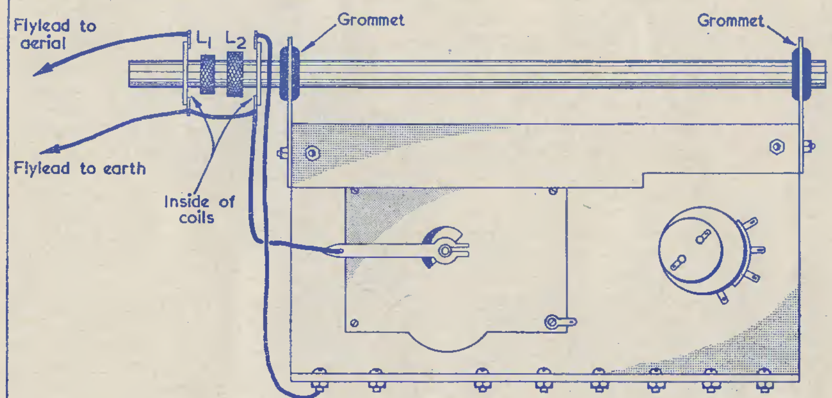

FIG. 19.

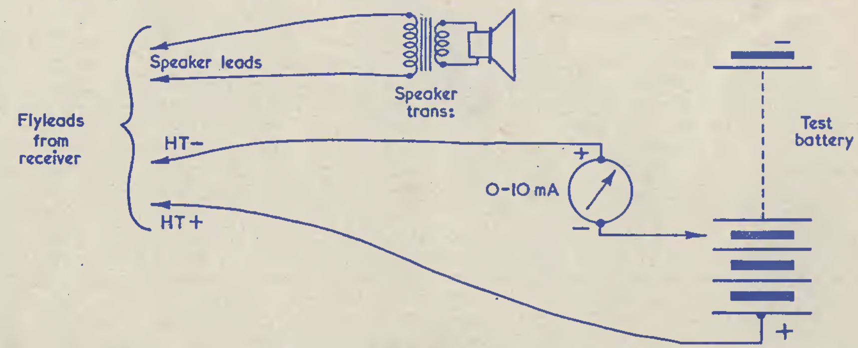

FIG. 20.

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Fig. 15. First stage in wiring the receiver. Fig. 16. Fitting the electrolytic coupling condensers and R_6. Fig. 17. The positioning of the components on the transistor tag-board

Fig. 18. Mounting the transistors themselves Fig. 19. The wiring connected to the aerial coil Fig. 20. The external circuit needed for testing the main chassis

black leads for the h.t. fly-leads (red connects to chassis). The speaker transformer fly-lead should be a different colour, again, from red or black.

The Tag-Board

Fig. 17 shows the transistor tag-board and the components which connect to it, with the exception of the transistors themselves. As will be seen, this diagram is quite self-explanatory and shows the various connections clearly. It should, nevertheless, be emphasised once more that all wires should be insulated with sleeving over their entire length. If the constructor wishes, however, the lead-out wires from the resistors need not, with two exceptions, be so insulated. The two exceptions are the lower leads of R_3 and R_5 which, travelling over a relatively long route, might possibly cause short-circuits if not covered with sleeving. The speaker transformer fly-lead shown in the diagram may be similar in length and colour to that of Fig. 16.

Next comes the fitting of the transistors themselves. As may be seen from Fig. 18, these are supported on their lead-out wires and lie flat against the tag-board between the appropriate tag spills. To prevent short-circuits, the end of the metal body of each transistor should be covered with a thin layer of tape, as shown in Fig. 18. The transistors will mount quite securely in position, although it may be necessary to bend the lead-out wires carefully before soldering each transistor into circuit. Care should be taken to ensure that the colour identification of the transistor lead-out wires corresponds to that shown in the diagram. All transistor leads must be covered with sleeving.

As was described above, the transistor connections are made by the use of "laid-on" joints, and not by twisting around the tag spill before soldering.

All that now remains is to fit the aerial coil and wire it up. The Ferrite core of the aerial coil is mounted as shown in Fig. 19. This core should be handled with great care as the material used is brittle. It should also, incidentally, be kept well away from the magnet pot of the speaker specified during tests as, otherwise, it is liable to be suddenly attracted to it with sufficient violence to become broken. In Fig. 19, reference is made to the inside connections of the two coils on the Ferrite rod. These connections may be identified by examining the coils themselves in order to see which lead appears from the inside of the coil concerned. The soldered connections to the coil tags should be made carefully to avoid damaging the coil wires themselves. Two more fly-leads (aerial and earth) are fitted at this stage. These fly-leads will be later shortened and connected to an aerial-earth socket strip.

Testing

The receiver should now be carefully examined to ensure that all connections have been correctly made, and agree with the circuit of Fig. 1. The set may then be tested.

To do this it is first of all necessary to connect up the loudspeaker and speaker transformer. The speaker specified has a very small diaphragm area, and it should be mounted on a small baffle to realise its full audible output. A temporary and quite effective baffle, or "cabinet," may be made by cutting a 2¼in diameter hole in a cardboard box and mounting the speaker therein.

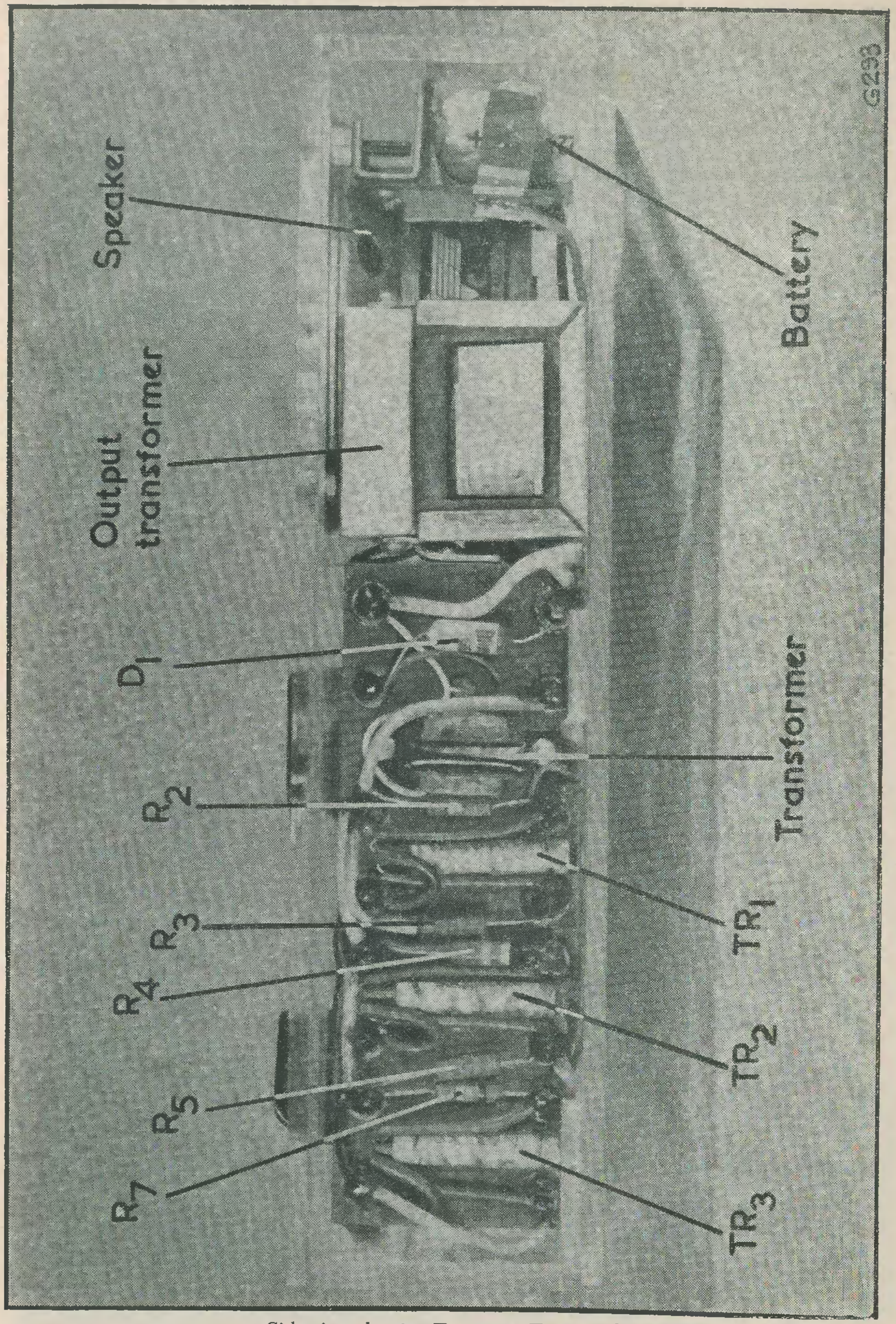
The aerial and earth leads are next connected up. Suitable aerial and earth systems were discussed in the first article in this series.

So far as a battery supply is concerned, it would be very advisable to check the receiver at a low h.t. potential before applying the full voltage. Any errors may then be made apparent, and the low voltage will not cause any damage. As an additional precaution, a milliammeter should be connected in series with the h.t. lead. A 0–10mA meter is specified here, although a meter with a suitable alternative f.s.d. can be employed, if desired. The range of readings to be expected will be between 1 and 6mA. A moving-coil meter is essential for this test, incidentally, as the relatively high resistance of a moving-iron meter may upset the stability of the receiver.

The whole set-up is illustrated in Fig. 20. As may be seen from this diagram, it is intended that the negative lead from the receiver should be tapped into the h.t. battery. The most practicable and satisfactory way of doing this would consist of using two 9 volt grid-bias batteries connected in series as a source of test h.t. voltage. Tappings could then be made in steps of 1.5 volts.

After connecting the speaker and aerial-earth system, the positive h.t. lead from the receiver should be connected to the positive end of the test battery. The set should be switched on, and the negative h.t. lead connected to the negative 3-volt tapping in the test battery, This should cause a slight crackle in the speaker, and the milliammeter should read 0.5mA. The negative lead should then be taken, in 1.5 volt steps and checking current at each step, up to 9 volts, at which potential the milliammeter should indicate approximately 1.4mA. A check should be made, at this point, for current surges at the instant of connecting the h.t. supply. Such surges should be negligible, if existent at all.

An h.t. potential of 9 volts is sufficient to operate the receiver at reduced sensitivity. When the h.t. is connected a gentle "rushing" noise should be audible from the loudspeaker. This is the hiss given by the transistors, and it has a greater amplitude than that given by a



Side view showing Transistor Tag Panel valve amplifier of similar gain, Turning the volume control will have little effect on the strength of the hiss.

The tuning condenser should next be rotated, whereupon it should be possible to pick up the local medium-wave transmitters. The volume control may also be checked for operation at this stage. It will be noted that loud signals will cause slight deflections in the h.t. milliammeter, and it should be possible to increase volume such that these deflections are quite large before noticeable distortion due to overloading sets in.

Assuming that everything is satisfactory, all that now remains is to increase the h.t. potential in further steps of 1.5 volts (still checking h.t. current at each step) until the full potential of 18 volts available from the test battery is given. At this potential the h.t. current should be approximately 2.8mA, the maximum safe current being 3.3mA.

The volume of the signal will, of course, increase as h.t. voltage is increased. The h.t. current readings should be made both under signal and no-signal conditions. At 18 volts, also, the volume control should be checked for smooth operation similarly; that is, under signal and no-signal conditions.

If everything is satisfactory at 18 volts, the 22.5 volt deaf-aid battery may now be connected to the receiver, whereupon the h.t. current should rise to approximately 3.8mA (maximum safe current 4.5mA). It may be mentioned at this point that it would be unwise to attempt to operate the receiver at an h.t. potential higher than 22.5 volts. If at any time during the test a.f. instability occurs, the h.t. voltage should be reduced until the cause has been located and cleared. Such instability can be caused, incidentally, if the output transformer is positioned too close (i.e. within an inch or so) to the deaf-aid transformer on the transistor tag-board. This point should be borne in mind if the chassis is housed in a cabinet of the constructor's own design.

Next Month

Apart from the cabinet, the receiver is now complete. These articles will be concluded next month with a description of the cabinet, and several further points concerning the operation of the set.

RADIO—AND CONTROL

PART 6. *by* **RAYMOND F. STOCK**

Many readers, particularly amateur radio transmitters, will know that a carrier frequency can be modulated by one audio signal to 100%, by two to a maximum of 50% (each), by four to a maximum of 25% (each), and so on. Obviously, if we require four *simultaneous* channels we can only use up to 25% modulation depth, and will probably use less. Coupled with the fact that a super-regenerative receiver is less efficient in rectification as the modulation depth is reduced, a good deal more amplification is needed at the receiver when more than one channel must be used simultaneously.

When a signal is applied to a resonant circuit the peak value of voltage across the circuit cannot appear instantly, and the higher the Q of the circuit the slower the rise. Irrespective of frequency, a certain number of cycles of the applied signal is required to build up the peak value; therefore the higher the *frequency* of the signal the shorter the *time lapse*. There is a physical limit to the size of reed which can be used to produce a useful vibration, and in practice this sets the upper limit of audio frequency at about 400 c/s. An electronic filter with the same equivalent Q might work at 4,000 c/s, so it can be seen that speed of working greatly favours the filter circuit. A practical range for reeds is the octave 200-400 c/s, while filter circuits often use 2-6 kc/s.

When either system is used it is necessary to choose the frequencies carefully. Not only must they be separated sufficiently to permit effective filtering (according to the Q of the filters) but if simultaneous working is required no combination of frequencies should produce a summation or difference frequency close to a channel frequency. Frequencies having a simple ratio (e.g. 2:1) must also be avoided.

Spring steel reeds have a naturally high equivalent Q, but special precautions must be taken to obtain a satisfactory separation when using filter circuits

Fig. 22 shows the common amplifier and one filter circuit, recently developed by the author to use 1.4V valves. Until now the practice has generally been to employ indirectly heated valves; this circuit has (in the author's case) cut consumption from 15 watts to 1.5 watts for a comparable 4-channel receiver. The complete circuit uses 11 valves, but the r.f. stage is omitted here as this can be of almost any type, for 27 Mc/s or 465 Mc/s, as required. The whole receiver, including r.f. stage (if 27 Mc/s) but excluding the relays, measures 4¼in × 3in × 2¾in.

The amplifier is a straight forward 2-valve (pentode) unit using a 1S5 and 1T4, the former well decoupled; its output is coupled by C_1 to the resistors R_1, etc., of the four filter circuits. The filter valve is a pentode (1T4) acting as an amplifier, the grid being returned to −1.5V bias. In the grid circuit is L_1-C_2 (the resonant circuit), which may be considered the lower part of a potential divider across the output of the amplifier; R_1 is then the upper part.

The voltage applied to the grid is very small off resonance, as the impedance of L_1-C_2 is so low compared to R_1. At resonance the impedance of L_1 C_2 rises considerably (according to their Q) and the large resultant signal voltage is applied to the grid, amplified, and passed on to the relay valve, a 3V4 triode-connected.

L_1-C_2 would have too low a Q if the choke were a simple iron-cored component, and in that case it would be necessary to rearrange the circuit using positive feedback from the anode to "sharpen" the tuning (compare reaction in r.f. stages). The introduction of modern high efficiency magnetic materials has, however, permitted the use of the simple circuit shown, and L_1 is, in fact, a Mullard Ferroxcube pot core type LA1. The inductance is, of course, varied from filter to filter, as is C_2; this condenser is the closest standard value to the required capacity, tuning being accomplished empirically by rubbing down the pot core to reduce its gap.

1T4 valves were used extensively, as many were to hand, but the 1T4 has

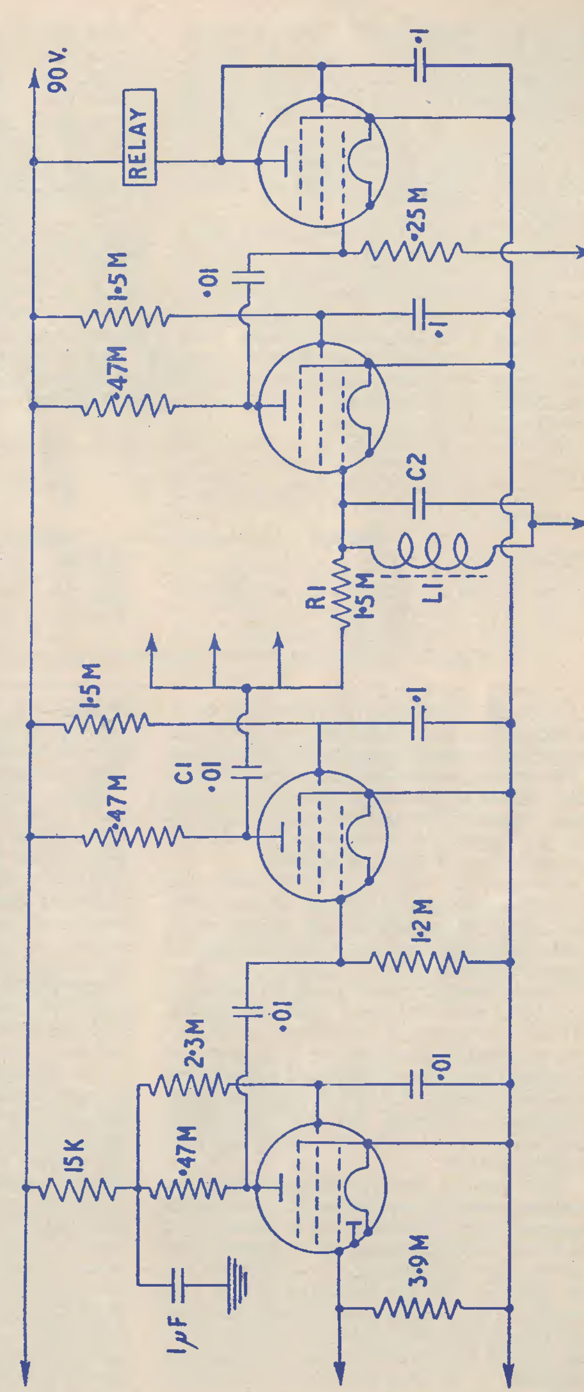


Fig. 22. Typical circuit for audio signal amplification and filtering

variable-mu characteristics and a linear grid-base valve would probably be better.

The transmitter for electronic filter circuits takes the general form of Fig. 23. No details are given, as exact design will be dictated by individual resources, choice between directly and indirectly heated valves, and, in many cases, the need to adapt an existing r.f. stage.

Each valve oscillator must show good frequency stability and can be an RC oscillator, or, better still, employ a high Q circuit built around a Ferroxcube pot core. Following the oscillator is a buffer amplifier, and keying is accomplished between these stages and the common modulator stage. The output from each buffer is normally earthed, and the stage keyed by breaking the contacts grounding it.

This type of oscillator gives a very impure output and a high depth of modulation; indeed, the object is to obtain over 100% modulation, so that the carrier is "chopped" at the audio frequency. This permits maximum efficiency and minimum amplification to be employed in the receiver. A 1S4 as modulator will just handle a pair of similar valves connected in the familiar push-pull r.f. arrangement. The use of anode modulation is assumed (and is also recommended for filter-circuit transmitters) but grid modulation is possible, more particularly with crystal controlled r.f. stages followed by power amplification.

It is hoped that full details of a practical reed system and a complete filter system may be described later.

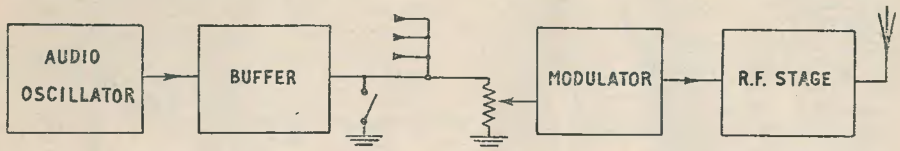


Fig. 23. Typical transmitter arrangement for use with electronic filters

Depth of modulation is controlled by a potentiometer in the modulator grid; it is also desirable to control the individual modulation depth by using a potentiometer in each buffer stage. Since it is necessary to apply a pure audio frequency to the filters, all stages in the transmitter and receiver should be designed to be as linear as possible.

Obviously a very wide field exists for original experiment in circuits of this type. The whole radio link can be treated in a similar fashion to that employed for orthodox communications work.

Transmitters for reed receivers have by now been well developed and their design virtually standardised. Simultaneous operation on separate channels could be obtained by using modulating equipment as described for filter receivers, but if this degree of complication is admitted one may as well fit filter circuits and reap the benefit of high speed operation.

Consequently, the type of gear which has emerged employs one valve as a combined oscillator and modulator. The circuit is a blocking oscillator using an l.f. transformer between grid and anode, whose frequency is set primarily by the resistance in the grid circuit. The resistance is actually provided by various pre-set variable resistors, each one tuned to a reed frequency, and each returned to earth via a pair of channel keying contacts.

General

It will be seen that there is no one best way of obtaining accurate control, and many compromises must be made.

Ideally, one must start by deciding the type of model, its performance and its control requirements, specified in the form of (1) what functions must be controlled, (2) what type of control will be used, i.e. positional (sequence or non-sequence), progressive or proportional, (3) control characteristics, if proportional, i.e. degree of resolution, speed of operation, etc.

The type of intergear and the design of the operator's controls can then be decided, and from this an assessment of the radio channels and their type can be obtained.

The intergear and control gear can then be made and adjusted. When working satisfactorily, the radio link can be tackled, and the complete control system tested. A suitable model may then be designed around the equipment.

This is a counsel of perfection, and an existing model, or a kit, may be the starting point. If this is so, one point above all others must be watched—never reduce battery capacity below the tested minimum in an attempt to suit a model that is really too small.

When the equipment is finished, make careful bench tests to determine the smallest size of batteries (for h.t., l.t. and intergear) which can give an economic life, and find out the minimum voltage required to maintain all functions. Thereafter, see that cells are changed before this minimum point is reached.

Observation proves that the besetting evil of radio controlled models is unreliability; attention to batteries will eliminate most of the trouble, while carefully polishing all contacts will look after the rest.

Finally, try to make the mechanical gear as reliable as the electronic equipment. Most small commercial motors are quite useless for serious work, and surplus motors should always be employed where practicable. Unless machining facilities are available, items such as gearboxes, relays, selectors and similar components are much better adapted from surplus equipment than made up by hand from old clock parts and electric bells.

Never use a mechanical device where there is an electrical or electronic alternative; *always* keep the essential minimum of mechanical gear as robust as possible—then by avoiding any chances with old batteries a first-class model may result!

Can Anyone Help?

Requests for information are inserted in this section free of charge; subject to space being available

C. V. Hawes, 24 Wannock Road, Eastbourne, Sussex, needs the circuit of the American Loran 1D-6 A/APN-4 using a 5CP1 c.r.t.

* * *

R. Martin of 8 Menin Road, Billesley, Birmingham 14 urgently needs the circuit diagram and servicing information for the Ferguson 204 BVX chassis, and is willing to forward the full cost.

* * *

K. R. Wilkinson, G3YP, 88 Talbot Road, Roundhay, Leeds 8, Yorks., wishes to buy or borrow the circuit and any other data on the W/S22 (crystal).

* * *

R. Hicklin, 13 Clive Road, Heath Park, Romford, Essex, would like to buy or borrow the circuit diagram and any information on the ex-W.D. Receiver R103, Mark 2, Ref. ZA.3080.

* * *

J. Cartledge, 39 St. John Street, Horwich, near Bolton, Lancs., wishes to buy or borrow circuit and/or handbook for the Naval P.22 receiver.

* * *

2727332 J/T Wade, E., S.H.Q. Signals, R.A.F. Martlesham Heath, Woodbridge, Suffolk, requires information on a German l.f. receiver used in Heinkels during the last war. The set uses seven r.f. pentodes (R.V.12 P.2000) and a stabiliser, and the band coverage is believed to be 150 to 1,200 kc/s. The size is 8in × 7in × 8in.

* * *

E. Adams, 69 Taunton Street, Landport, Portsmouth, requires on loan or for purchase the circuit or any other information on the receiver R.1392D, ref. 10/17745.

R. Vincent, 26 Alma House, Sebastopol Road, Edmonton, London N.9, would like to buy or borrow the service data for a Philips model T.V. 663A.

* * *

V. Anderson, 149 William Barefoot Drive, Mottingham, London S.E.9, would like to obtain any circuits or literature concerning mixer units for microphones, with a frequency response of the order of 30 c/s to 15 kc/s.

* * *

M. E. Tinson, 13 Whitelock Road, Abingdon, Berks., is anxious to learn where he can obtain ready-made laminations for record/playback heads, or alternatively some unserviceable heads which he can break down for same.

* * *

Z. Lewis Williams, 30 Brooklands Avenue, Sidcup, Kent, wishes to convert a Canadian walkie-talkie type 58 for use on the 80m and 160m bands, and would like to obtain information which will enable him to accomplish this.

* * *

E. Robinson, 10 Pye Nest Drive, Pye Nest Road, Halifax, Yorks., wishes to obtain information on the BC.453.B Command receiver.

* * *

R. Bond, 118 Gartcraig Road, Glasgow E.3, wishes to obtain circuit, data, manual etc., for the transmitter TR1154M.

* * *

F. A. Hunter, 10 Seventh Street, Wallsend-on-Tyne, Northumberland, requires information on the transmitter T.1403, in particular the power connections.

Building the MULLARD 3-VALVE 3-WATT HI-FI AMPLIFIER

For the reader who is thinking of building an amplifier that must be simple to construct, which will provide an output power adequate for most homes, and which will have a distortion level low enough to warrant it being included in the highest quality class reasonably expected of such a simple design, this Mullard circuit has much to commend it.

Built to provide an output power of the order of 3 watts, with an input signal of 100mV, it would be a difficult job indeed to reduce the number of valves employed and yet retain the same high standard of performance, particularly also in regard to low hum and noise characteristics.

Much more than the usual voltage gain is demanded to be able to satisfy this requirement of input sensitivity and the provision of a negative feedback factor of 10 times (20db).

Designed round the popular Mullard nine-pin (B9A based) all-glass valves, an EF86 input pentode as the first stage voltage amplifier feeding a high-slope output pentode type EL84, and an indirectly heated full wave rectifier type EZ80, this aim has been successfully achieved by departure from the usual method of employing a pentode valve, and operating the first stage under so-called "starvation" conditions, which enables the effective stage gain to be virtually doubled. The valve currents and voltages are much lower than is the case under normal operating conditions, due to the high value of anode load used (2.2. Megohms), and the unusual way of supplying the screen grid of the EF86 from the cathode of the EL84 output valve which provides d.c. negative feedback, and also stabilises the valve working points.

Any type of crystal pick-up can be used, and the high sensitivity of the amplifier (only 100mV for 3 watts output) will be sufficient to offset the insertion loss of any equalising networks desired between pick-up and the input stage.

As will be seen from the circuit diagram (Fig. 1) three variable controls are provided, volume (RV_1), treble (RV_2), and bass (RV_{14}).

With the treble and bass controls in their minimum effective positions, the overall frequency response is substantially flat within ±1db from 100 c/s to 10 kc/s. This is indicated in the graph, Fig. 3, which shows the relative gains, with both tone controls in the minimum position, and also with the treble control in the maximum cut, and bass control at maximum boost, positions.

It will further be seen that it is possible to reduce the treble response at 10 kc/s by a factor of 15db, and to boost the bass response at 100 c/s by a factor of 12db, both relative to the response level at 1 kc/s.

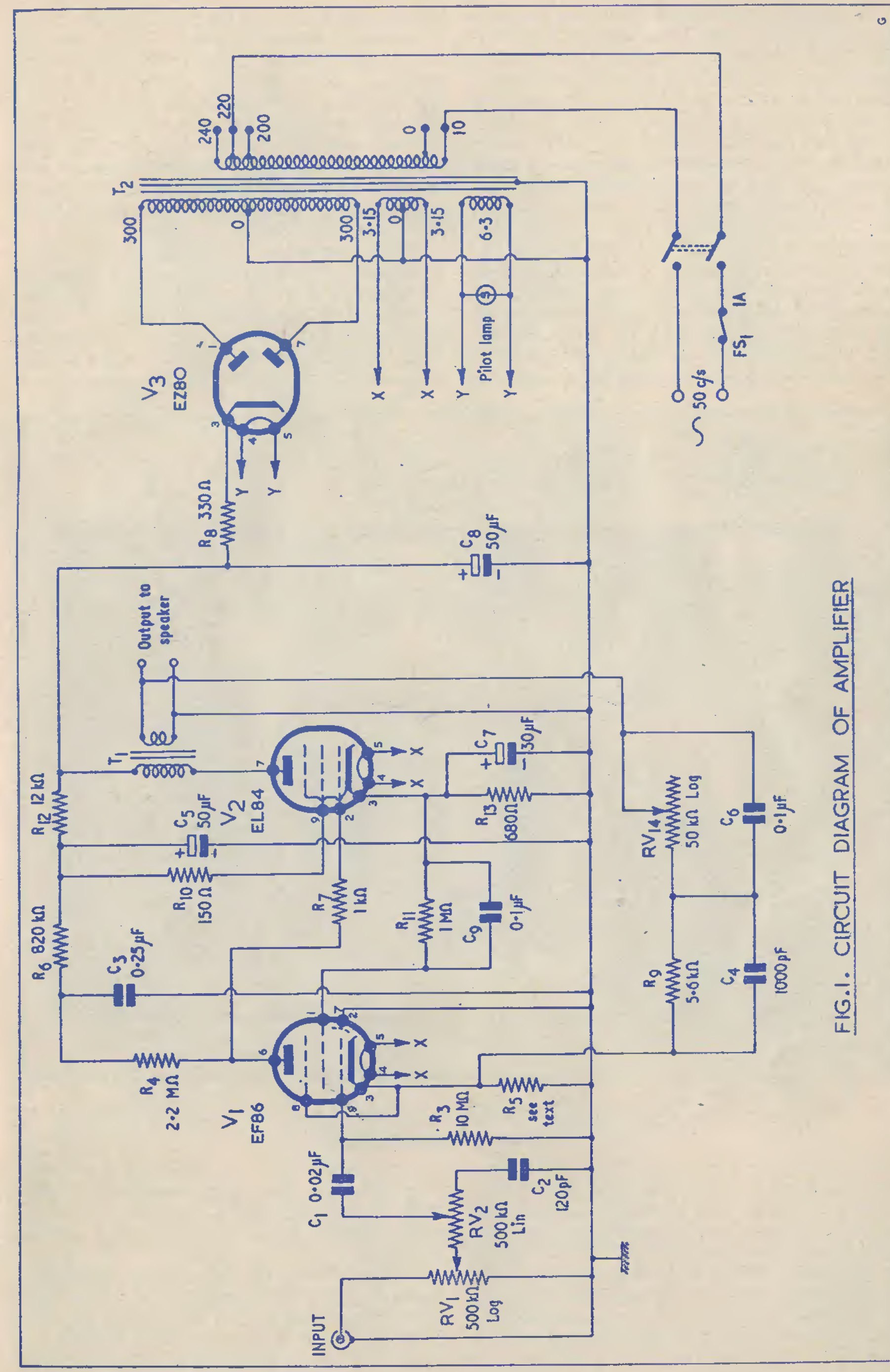
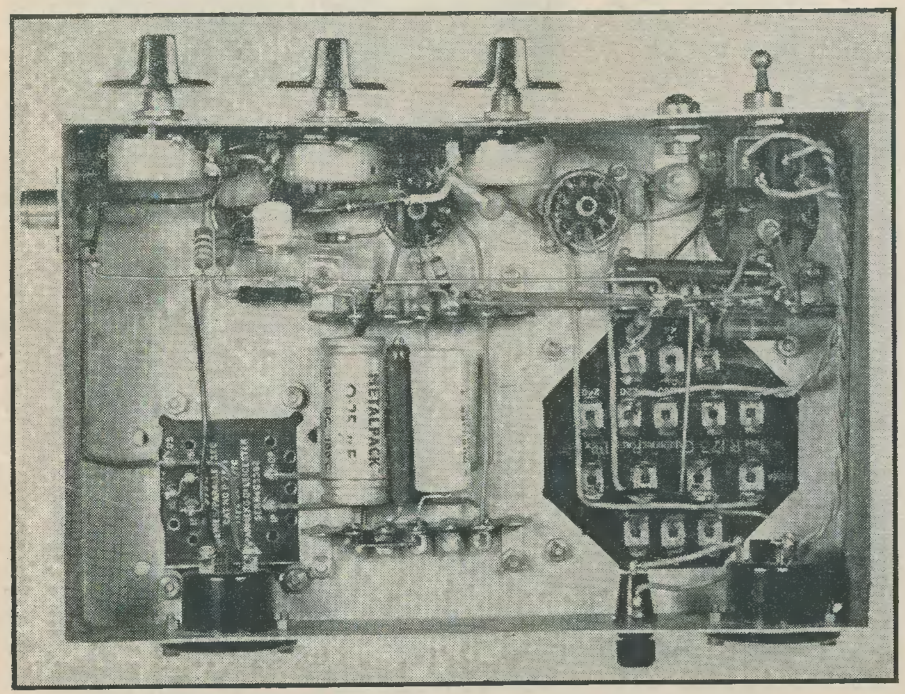


FIG.1. CIRCUIT DIAGRAM OF AMPLIFIER

A design feature which should be noted is that maximum bass boost occurs at about 120 c/s, below which frequency the effective boost decreases at a rate of 12db per octave. This can be a very useful device for lessening possible motor rumble and hum troubles.

Whilst on the subject of hum, much trouble can be avoided by attention to small things. By this is meant, for example, that a good quality valveholder should be used for the EF86, preferably of the nylon-loaded or Mykacin types; the heater leads from the mains transformer to the valveholders should be twisted; the screened pick-up lead usually provided by thoughtful manufacturers should be earthed, together with the earth tag on the motor board; care must be taken in to run the heater of the 6.3V rectifier from a separate heater winding); keep the high impedance pick-up leads as far as possible from a.c. fields; make a really clean job of the wiring-up, which should follow closely the point-to-point diagram in Fig. 2. The writer would be the first to agree that any constructor worthy of the name would not have failed to keep most if not all the points mentioned in mind, but nevertheless still feels they are worthy of mention.

Where the can of the 50+50μF electrolytic capacitor is used as the common negative connection, it must be isolated from the metal chassis, as otherwise the a.c. ripple current flowing may give rise to considerable hum. A bottom metal cover plate to the



Under-chassis arrangement of prototype—compare the point-to-point diagram shown on the opposite page

running leads carrying a.c.—these obviously should be kept well clear of control grid wiring; multiple earth connections on the chassis will only result in a number of earth loops, with inevitable noisy results. The earth connection to the chassis must be made at the input socket ONLY! Use a transformer with a centre-tapped heater winding to feed the EF86 and EL84 (it is also good practice amplifier has not been found necessary. With reasonable care a hum/noise level of 70db relative to the rated 3 watts can be obtained.

Fig. 4 shows total harmonic distortion plotted against output power. It will be seen that at the rated output of 3 watts, the distortion level is 1.5%, but that beyond 3.5 watts the onset of distortion is fairly rapid,

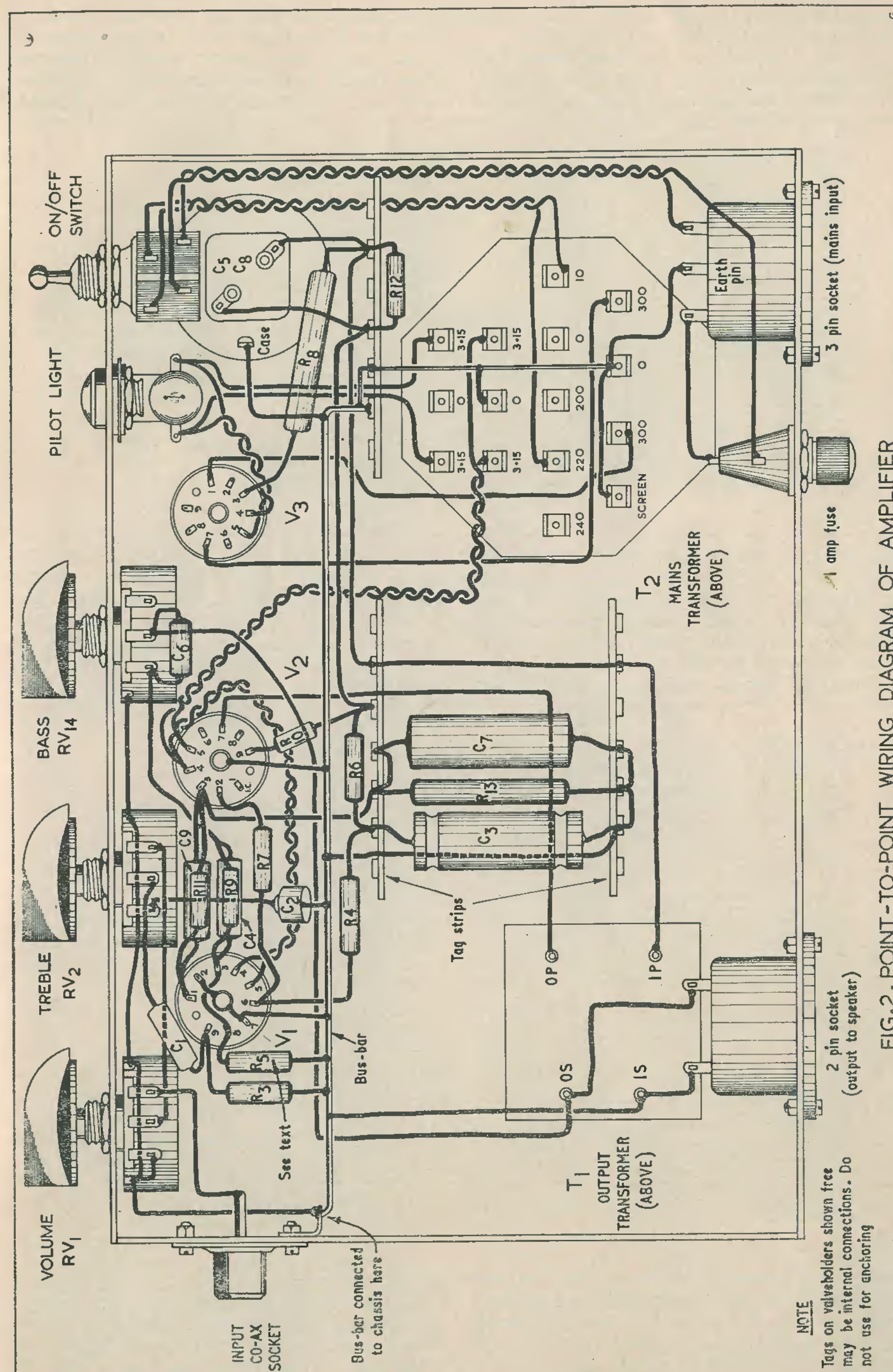


FIG.2. POINT-TO-POINT WIRING DIAGRAM OF AMPLIFIER

being indicative of the point where overloading of the amplifier is taking place.

In the "shopping list" of components will be seen several types of output transformers of different makes which have been tested out in this circuit, and which have been found to be in every way satisfactory. This is probably the most important part of a good quality amplifier, and you are strongly advised to use one of these types which have been approved by the Mullard Application Laboratory design engineers. This is not intended to imply that positively no other make of transformer will be suitable, but if in your quest for a specified type you are offered a substitute, be firmly assured by a reputable dealer that the electrical characteristics are at least identical. Insistence on this point will at least ensure freedom from the poor results that could otherwise be expected were a cheap product to be used instead.

There must be no confusion between the terms "cheap" and "inexpensive" where output transformers are concerned. The 3.75 ohm and 15 ohm output terminations should enable the correct matchings to be made to almost any kind of moving coil loud speaker.

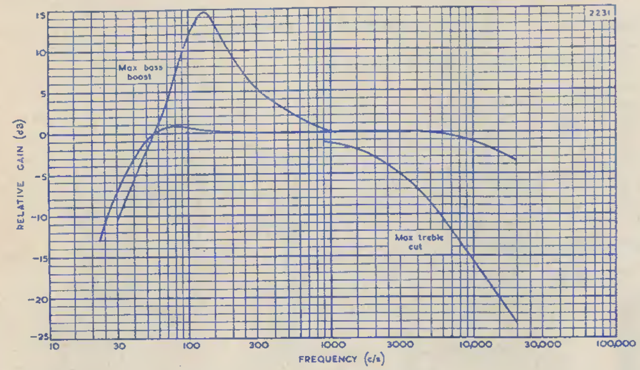


Fig. 3. Frequency response of amplifier, showing relative gain with minimum tone controls, and also with maximum treble cut and maximum bass boost

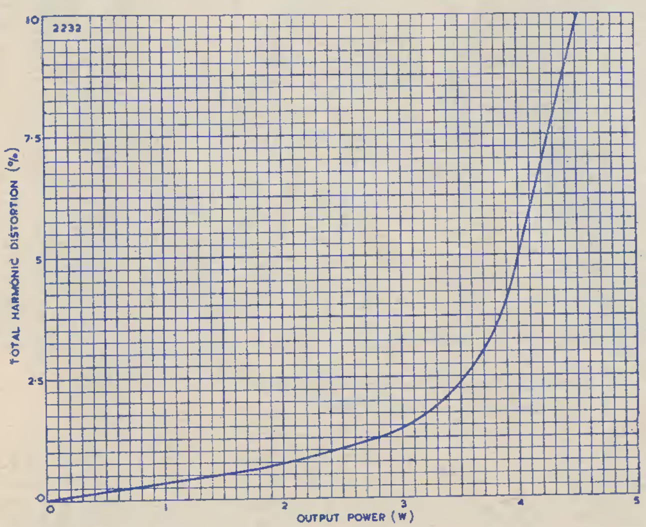


Fig. 4. Total harmonic distortion plotted against output power

If on testing the amplifier you hear a howling or hooting noise (gentle or otherwise depending on the position of the volume control!) it is only necessary to switch off and change over the two connections to the output transformer secondary. The unwanted effects of positive feedback will then be corrected to the negative feedback required.

Note that the value of the feedback resistor in the cathode circuit of the EF86 must be chosen to match the voice coil impedance of your loudspeaker, i.e. R_5 must be 150 ohms for a 3.75 ohms load, or 82 ohms for a 15 ohms load.

A chassis of dimensions 9in × 6in × 2½in will be required. Osmor Radio Products Ltd. have a chassis punched available.

The photograph and point-to-point wiring diagram of the underside view of the prototype amplifier provide details of the recommended layout. The designers have put a considerable amount of thought into this, and you cannot do better than copy their layout as closely as possible.

The mains transformer should have a 300-0-300V secondary winding, rated at 60mA, preferably with a separate rectifier winding (6.3V) for the EZ80. A transformer designed for the Mullard 5 valve 10 watt amplifier circuit for LOW LOADING operation would be very suitable for this equipment.

When wiring up the valveholders, bear in mind that any valve pins marked "IC" on the diagram means that they may carry an internal connection in the valve itself. The corresponding sockets on the holders must *not* therefore be used for supporting any wiring.

A brief word on the subject of loudspeakers may not be out of place as concerning the final, and very important, link of the electro-acoustic chain.

(*continued on page* 579)

Component List

Resistors

RV_1 500kΩ carbon log pot.
RV_2 500kΩ carbon linear pot.
R_3 10MΩ ±20% ¼W
R_4 2.2MΩ ±10% H.S.
R_5 82Ω for 15Ω load / 150Ω for 3.75Ω load } ±10% ¼W
R_6 820kΩ ±10% ¼W
R_7 1kΩ ±20% ¼W
R_8 330Ω ±20% 2W
R_9 5.6kΩ ±10% ¼W
R_{10} 150Ω ±20% ¼W
R_{11} 1MΩ ±10% ¼W
R_{12} 12kΩ ±10% ½W
R_{13} 680Ω wirewound ±5% 3W
RV_{14} 50kΩ carbon log pot.

Capacitors

C_1 0.02μF paper 150V min.
C_2 120pF ±10% S.M. or ceramic
C_3 0.25μF paper 350V wkg
C_4 1000pF ±10% S.M. or ceramic
C_5, C_8 50-50μF electrolytic 350V wkg
C_6 0.1μF paper 150V min.
C_7 30μF electrolytic 50V wkg
C_9 0.1μF paper 150V min.

Valves

EF86, EL84, EZ80, all Mullard

Chassis

Ready drilled, Osmor Radio Products Ltd.

Fuse

1A, Belling-Lee, Minifuse, L575

Tag Strips

Bulgin, T24, 5-way. Three required

Output Transformer

T_1 Primary: 5000Ω
Secondary: 3.75Ω or 15Ω

The following have been tested in the circuit and found to be satisfactory:

Manufacturer	*Type No.*
Colne	35206
Gilson	WO767
Parmeko	P2641
Partridge	SVO/1
Wynall	W.1452

Mains Transformer

T_2 Primary: 10-0-200-220-240V
Secondaries: H.T. 300-0-300V, 60mA
L.T. 3.15-0-3.15V, 1A (for V_1, V_2)
6.3V, 1A (for V_3)

If only one 6.3V heater winding is available, it should have a 2A rating to supply all three valves.

Sockets

Mains input: Bulgin, 3-way
Output: Bulgin, 2-way
Coaxial: Aerialite, 149

Pilot Lamp

Bulb: 6.3V, 0.04A
Holder: Bulgin, D180/red

Valveholders (three required)

Noval (EF86 skirted—see text)

Mains Switch

230V, 2A, double pole toggle, Bulgin S300

The ARGONAUT

A.M.-F.M. M.W.-V.H.F. TUNER-RECEIVER

PART 2.

by G. BLUNDELL

Choice of Components

THE CHOICE OF COMPONENTS IS ALWAYS more difficult when attempting to meet the requirements of v.h.f. circuitry, and the component list should be carefully followed.

Wrong types of components can spoil an otherwise good performance. For example, the f.m. oscillator grid and g_2 coupling condensers C_6 and C_8 are specified as silvered mica; the use of ceramic condensers here will cause tuning drift—as, indeed, it does in other *Jason* f.m. tuners. The 1,000pF bypass condensers in the r.f. stages must be ceramic, and not metallised paper. The latter type condensers are slightly inductive and will cause parasitic oscillation. In fairness to the manufacturers, it should be stated that 90 Mc/s is above their frequency ratings for this type.

The 0.005μF condensers in other parts of the circuit should be ceramic, as the equivalent silvered or moulded mica condensers are physically too large. The medium wave oscillator tracking condenser C_{13} should be of the value and accuracy quoted, otherwise it will not be possible to align the M.W. scale accurately.

The output valve grid coupling condenser C_{30} is quoted as 500V wkg, since any leakage will cause damage to this valve.

The 0.01μF condensers C_{30}, C_{31}, C_{32} and C_{33} may be ceramic, instead of the more usual paper, if suitably small components are available.

A twin trimmer is available for TC_3 and TC_4, and the chassis is drilled for this.

Testing and Aligning

Before switching on, check that there is no h.t. line short to chassis in any position of the F.M./A.M. changeover switch. Connect a 500V meter to the h.t. line and chassis, and switch on. The dial lights should, of course, light immediately, and voltage should appear on the h.t. line as soon as the rectifier warms up. If not, switch off immediately to avoid possible damage, and check again for h.t. line shorts and for faults in the power supply section. When voltage appears on the h.t. line, quickly check that voltages are approximately correct at the various test points as given in the table. If so, proceed with the A.M. alignment.

A.M. Alignment

Do not attempt the alignment unless some results are achieved. The coils supplied by *Jason* are approximately aligned, and it should be possible to get something from the local transmitter. If not, check as described later in the Trouble Shooting section.

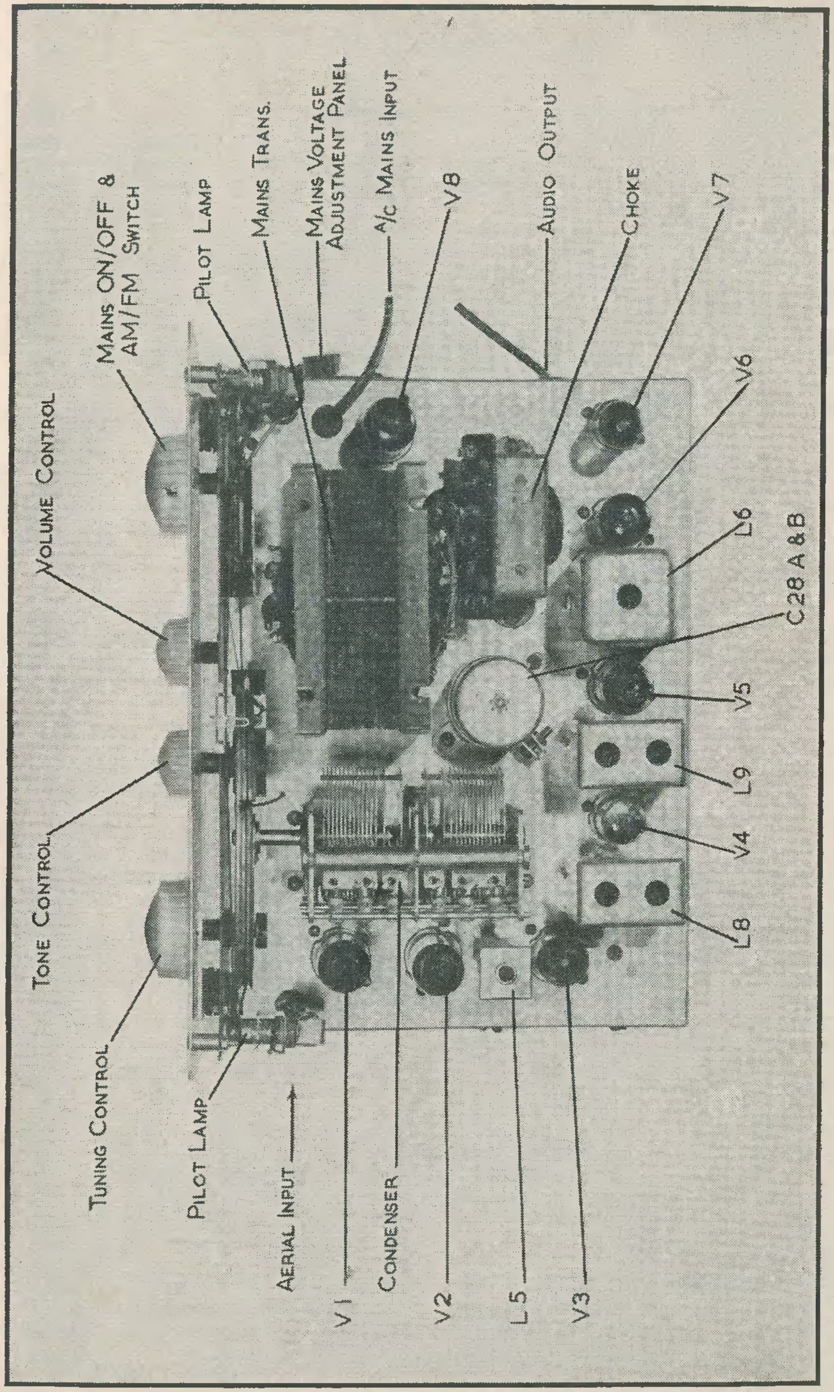
An indicator of some sort will be required. An oscilloscope may be used, or a 10V meter with a 10,000Ω/V movement may be connected from the junction of R_{22} and C_{21} to chassis. Alternatively, a 1,000Ω/V meter (0-1mA movement) set to the 250V range may be connected from the screen grid of V_4, pin 6, to chassis. This voltage will vary in accordance with the a.v.c. voltage derived from the detector.

Also required is a signal generator with internal modulation. Connect this to V_3 at the junction of $L_{5(b)}$ and the control grid (pin 2), and set the generator to 472 kc/s. Adjust the uncoded cores of L_8 and L_9, top and bottom. Check that the i.f. curve is reasonably balanced by detuning the signal generator either side of 472 kc/s. This frequency is chosen rather than 465 kc/s because the latter produces a whistle on the London Home Service programme.

Reduce the signal generator output to the minimum possible consistent with obtaining a reasonable indicator reading. This is necessary because a large a.v.c. voltage results in reduced sensitivity of tuning of the i.f.t. cores.

Alignment of M.W. R.F. Circuit

Connect the generator to the aerial socket with a 200pF condenser in series to act as



Top view of the "Argonaut", with all components identified

Test Voltages measured with a 1,000 ohms per volt Meter on the Prototype switched to F.M.

Valve	Type	Measurement point	Voltage receiver choke smoothing	Voltage tuner resistance smoothing
V_8	U709	Rectifier cathode C_{28A}	270	320
,,	,,	H.T. rail C_{28B}	235	200
V_1	Z719	R.F. stage decoupling R_1 and R_2 ..	190	165
,,	,,	R.F. anode voltage R_2, C_5	140	120
,,	,,	R.F. stage cathode R_3, C_4	2.3	1.8
V_2	,,	F.C. anode decoupling R_5, C_7	195	165
,,	,,	G_2 (Oscillator H.T.) R_7, C_8	90	80
V_3	X79	G_2 and G_4 1st F.M./I.F. R_9, C_9 ..	75	70
,,	,,	H.T. 1st F.M./I.F. R_{13}, C_{14}	205	175
V_4	W727	G_2 voltage 2nd F.M./I.F. R_{20}, C_{18} ..	80	70
,,	,,	H.T. 2nd F.M./I.F. R_{16}, C_{17}	200	170
,,	,,	Cathode 2nd F.M./I.F. R_{18}, C_{19} ..	0.8	0.7
V_5	Z719	Limiter H.T. R_{25}, C_{23}	40	35
V_6	N727	Cathode voltage R_{28}, C_{29}	12	—
Alternative V_3—ECH81				
V_3	ECH81	G_2 and G_4 1st F.M./I.F. R_9, C_9 ..	95	90
,,	,,	H.T. 1st F.M./I.F. R_{13}, C_{14}	185	160
,,	,,	Cathode voltage R_{39}, C_{38}	1.5	1.2

Test Voltages when switched to A.M.

Valve	Type	Measurement point	Voltage receiver choke smoothing	Voltage tuner resistance smoothing
V_8	U709	Rectifier cathode C_{28A}	285	330
,,	,,	H.T. rail C_{28B}	255	250
V_3	X79	G_2, G_4 M.W./F.C. R_9, C_9	65	65
,,	,,	H.T. M.W./F.C. R_{13}, C_{14}	240	235
,,	,,	H.T. Oscillator R_{11}, C_{12}	75	80
V_4	W727	G_2 voltage I.F. R_{20}, C_{18}	85	80
,,	,,	H.T. voltage I.F. R_{16}, C_{17}	215	210
,,	,,	Cathode Volts I.F. R_{18}, C_{19}	0.9	0.9
V_6	N727	Cathode volts R_{29}, C_{29}	12.5	—
Alternative V_3—ECH81				
V_3	ECH81	G_2 and G_4 F.C. R_9, C_9	90	90
,,	,,	H.T. F.C. R_{13}, C_{14}	220	215
,,	,,	Cathode voltage R_{39}, C_{38}	1.6	1.6
,,	,, ..	H.T. Oscillator R_{11}, C_{12}	75	75

a dummy aerial. If the generator is connected directly to the aerial input, the low resistance of the generator will prevent accurate tuning of the M.W. grid coil. The first part of the R.F. alignment consists of making the oscillator section follow the medium wave scale. Set the generator and receiver to 600 kc/s (500 metres) and adjust the core of the oscillator coil L_{11} until the generator note is heard. Now reset the generator and receiver to 1,200 kc/s (250 metres) and adjust the oscillator coil trimmer TC_4 until the note is again heard. This second adjustment will have affected the first, and will itself be affected by further adjustment of the first, so it will be necessary to repeat both operations several times until no further improvement can be obtained.

A.M. Alignment without Instruments

The coils supplied by the Jason Motor & Electronic Co. are approximately aligned, and therefore the tuning of the i.f.s will be more or less correct as received. Proceed with the scale adjustment as before, but using the Third programme wavelength on 647 kc/s (464 metres) for setting the low frequency end of the scale, and the Light programme on 1,214 kc/s (247 metres) for the high frequency scale settings. Other possible station wavelengths and/or frequencies for checking may be found in the *Radio Times*. Using a very short aerial—just sufficient to give an audible signal—adjust the aerial coil core and trimmer to produce maximum gain on both stations as previously instructed.

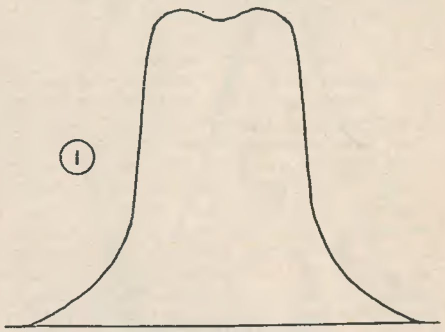
F.M. Alignment

The same instruments as before are required. Connect the indicator to the junction of R_{23} and C_{22} using a resistance in series with the indicator. This resistance should be mounted close to the junction of R_{23} and C_{22}, the object being to prevent detuning of the i.f.t. L_9 by the leads of the indicator. If a 1,000 ohms per volt meter is being used, set to the 250V range and connect to the junction of R_1 and R_2. This voltage will indicate resonance because a.g.c. voltage is fed back from the limiter grid to the grid of V_1.

Set the generator to 10.7 Mc/s and connect to the grid of V_4 and align the 10.7 Mc/s sections of L_9 which are colour coded black. Connect the generator to grid of V_3 and align the black coded cores of L_8. Lastly, connect the generator across L_3 at the junction of L_3, R_4 and C_6 and then adjust L_5. Having completed this, check that all settings are keeping the bandwidth as narrow as possible. By detuning the generator, ensure that the final curve is reasonably balanced around 10.7 Mc/s.

Alignment of the Ratio Detector

Connect the generator to V_4 grid. Remove R_{27} and replace with two 6.8kΩ $\pm 5\%$ resistors in series in order to make a centre tap on the ratio detector circuit. Connect the indicator between the centre tap and the junction of R_{26} and C_{25}. Adjust the primary to give a maximum reading and the secondary winding to produce a minimum reading. As the secondary tuning point is approached, there should be a swing of voltage in one direction followed by a voltage swing in the opposite direction. The actual zero tuning position should be quite sensitive; should this not be so, then the correct point has not been found. To finally tune the primary, offset the secondary slightly and then peak this residual reading by tuning the primary. Finally reset the secondary.



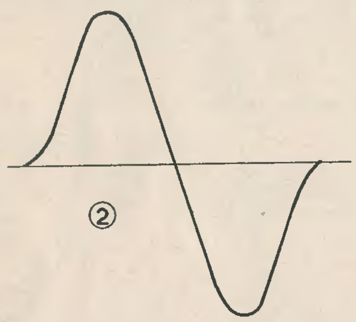
W10

Balanced I.F. curve

Alignment using a Wobbulator

Alignment by means of a wobbulator is by far the best method of achieving the ideal result since the effect of each adjustment is very much clearer. Faults are also more readily observed, particularly instability, which is immediately seen by distortion of the curve just prior to the stage under adjustment bursting into oscillation. Experience soon shows just how fast the curve shown on the screen should rise, and more rapid increases of the rise in effect predict instability prior to any actual trouble being experienced.

Connect the 'scope to the junction of R_{23} and C_{22}, using a 100kΩ series resistor to prevent detuning effects. Set the wobbulator to 10.7 Mc/s and the sweep width to approximately 1 Mc/s. Feed either into the wobbulator or the output lead a 10.7 Mc/s signal, then adjust the amplitude of this signal to give a small mark on the cathode ray tube trace, around which the curve should be balanced. Connect the wobbulator to the grid of V_4 and adjust L_8 in order to obtain a curve similar to that shown in the diagram. To align the ration detector, connect the 'scope to the junction of R_{26} and C_{25}, increase the marker amplitude and adjust L_6 to give a curve as shown in the drawing. The marker amplitude should now be increased as far as possible without reducing the amplitude of this curve. Next, connect the 'scope back to the initial test point and the wobbulator to the grid of V_3 and align L_8. Following this, connect the wobbulator to L_3, at the junction of R_4, C_6 and C_5, and adjust L_5. Finally, check all the core positions, making the bandwidth as narrow as possible consistent with the reasonable balance of the curve.



Ratio detector curve

Alignment of the F.M. Scale

Set the scale approximately by adjusting the F.M. oscillator trimmer TC_2. If a high frequency generator is available, set this to 100 Mc/s and readjust the trimmer. Should such a generator not be available, then use the Home and Light programme wavelengths. Should the stations be too close on the scale, the oscillator coil inductance should be decreased by parting the turns and slightly readjusting the stations with the trimmer. Next, tune the mixer grid circuit by adjusting TC_1 and by parting the turns of L_3 until maximum gain is achieved from both stations. Following this, re-check the scale tuning.

Tuning Core Positions—A WARNING

The coils are approximately pre-tuned when received and therefore the final tuning of the core may entail withdrawing this somewhat. It is however possible to obtain a false peak by adjusting so that one of the cores lies midway between the windings of each coil. Both cores appear to peak tune but the resultant gain will be not only of a low order but the bandwidth will be very wide. If in doubt, measure the depth of the core within the former.

Alignment the Easy Way

The Jason Motor & Electronic Co. will align the tuner providing that the layout diagram has been followed and that the instructions generally, particularly lead lengths, have been faithfully followed as outlined in this series.

Trouble Shooting

Many possible faults may be circumvented by adopting the correct layout as specified herewith, and it is assumed that this will be done by intending constructors. As an example of the possible outcome of alteration in layout, is the following—the layout drawing clearly shows R_{24} mounted near L_9; placing this resistor near to V_1 will inevitably produce i.f. instability.

Of great advantage when trouble shooting is the humble voltmeter aided by the test voltage tables. Reference to these will clearly indicate most valve faults and short circuits. A low voltage at V_5, junction of R_{25} and C_{23}, which rises when the valve is removed, indicates a grid 2/grid 1 short within the valve or an h.t. short to the a.v.c. line—or even a grid 2/grid 1 short within V_1 which would have the same effect. If the i.f.s have been aligned correctly but the tuner does not receive stations, the oscillator voltage may be checked using a sensitive meter and a 100kΩ resistance as a probe. A finger placed on the grid of V_2 should cause a considerable noise; if not, then there may be a grid 2/grid 1 short in the valve or a grid wiring short. Failing this, C_6 may be short circuited.

Errata. In the point-to-point diagram (last issue), the "earthy" end of L_1 secondary was shown connected to an earthing tag. It should have been taken to the tag above, i.e. to the a.v.c. line.

BAND III TELEVISION, *continued from page* 552

Band III aerial. The television receiver was a Murphy V120, tuned to Channel 4. The receiver was then retuned to Channel 1 and, with the Mark II Converter, transported to High Wycombe, Bucks. Tests were then again carried out using the same type of aerial. The signal picked up from the London Band III transmitter was of first-class quality, and was almost double the strength of the Band I signal using a 3-element Band I aerial.

No further comment seems to be necessary, as the results speak for themselves.

RIGHT—*From the Start*

PART 4. THE VALVE

by **A. P. BLACKBURN**

To the expert and layman alike, the thermionic valve is nowadays no longer an object of wonder. It has become sufficiently well known for it to be taken for granted by all except, perhaps, the very young. The familiarity which it enjoys, however, has the disadvantage that the layman is instinctively mistrustful of it; should his radio set suddenly fall sick or die, the valve is immediately blamed for failure. It would seem that no other component in the set is so temperamental or spitefully unreliable as the unhappy valve—an idea which, though hopelessly wrong, nevertheless persists with the uninformed.

If we can get to know the valve and its nature better, we shall be able to see how unjust this treatment is.

The primary purpose of most valves in radio receivers and amplifiers is to provide amplification. The tiny voltages produced by gramophone pick-ups, microphones, etc., require considerable amplification before they can be applied to a loudspeaker for the production of audible sounds.

In receivers, valves are used to amplify the tiny signals picked up by the aerial. In this article, however, we will only consider the "audio" applications; that is, amplifiers dealing directly with signals of frequencies within the audible range.

Conversion

Fig. 1 shows a block diagram of a simple audio system. Sound is transmitted by disturbing air. These disturbances travel from the source to the sensitive ear of the listener. The job of the microphone in Fig. 1 is to convert these disturbances of the air into electrical "disturbances," in other words, to produce voltages or currents varying in the same manner as the sound itself.

At A in the diagram there will be a small signal voltage which represents the sound striking the microphone. This voltage will be very small, so the amplifier has to increase it until it can be fed to the loudspeaker with sufficient power to be reconverted into audible sound.

The amplifier, then, has to amplify voltages of frequencies within the audible range, i.e. 16 c/s to 20 kc/s.

Electron Emission

The simplest type of valve is the diode. This has no property of amplification, but the principle of electron emission is most easily demonstrated in this type. Fig. 2 shows the structure of a very elementary type of diode, together with its circuit. The battery A heats the filament; electrons at the filament surface are released but fall back, rather like the tiny drops on the surface of boiling water. If a metal plate (B) is placed near the filament and a positive potential given to it, the electrons will leave the filament and impinge upon the plate. The flow of electrons from filament to anode, as the plate is called, represents a flow of current, just as though a wire had been connected between them.

The electron, which has a negative charge, is only attracted to a body having a positive charge. If the anode plate were charged negatively, i.e. the battery C were reversed, the electrons endeavouring to leave the heated filament would be repelled by the plate. No electron flow would occur and no current would flow from filament to anode. This is the first important property of the valve. Current will only flow in one direction. We will see later that this is of especial importance in the diode. However, as we are interested at the moment in valves as amplifiers, we will move on to the triode.

The Triode

A triode valve connected to its supplies is shown in Fig. 3. As in the diode, the filament is heated by the battery A and the anode is connected to the positive plate of the battery C. We now have a separate electrode, however, inserted between the anode and the filament. This is called the grid. It consists of a spiral of fine wire wound around the filament, but not in contact with it: this is shown in Fig. 4. The action of this electrode is illustrated in Fig. 5. If the grid is connected to the filament, it is at the same potential as the filament. The electrons leaving the filament pass through the grid and reach the anode. A small number may hit the grid, but the majority will pass through as shown in Fig. 5. If the battery D is now connected so that the grid is negative with respect to the filament, the electrons will be repelled by the negatively charged grid. Some, however, will still manage to leak through and reach the anode. The fact that fewer electrons reach the anode means that a smaller current is flowing between filament and anode. As the voltage of D is increased, the current will become less and less, until current ceases to flow entirely. Summing up, it means that the *anode current* may be varied by the *grid voltage*. Now we can get down to the triode as an amplifier.

Gain

Fig. 6 shows the triode once again, but this time there is a resistor connected between the anode and the battery C. This battery is called the high tension or h.t. battery. We have also arranged a switch in the grid circuit to switch from a one volt battery to a two volt one. We will start with the grid connected to the 1 volt battery and assume a current of 0.005 amps (5 milliamps) to be flowing from anode to cathode of the valve. Now suppose the h.t. battery has a voltage of 120 volts and the resistor R (called the anode load resistor) has a value of 10kΩ. The voltage between anode and filament of the valve must be 120V minus the voltage dropped across R due to the 5mA of valve current flowing through it. We can work out the voltage dropped across R from Ohm's law, as we saw last month.

From Fig. 6, $V_L = IR$.

$\therefore V_L = 0.005 \times 10{,}000 = 50$ volts.

The voltage between anode and filament of the valve is, therefore

$120 - 50 = 70$ **volts**

Now we will assume that if the grid switch is connected to the 2 volt battery the current through the valve will fall to 2mA. The volt drop across R will now be

$V_L = 0.002 \times 10{,}000 = 20$ volts

and the volts across the valve will therefore be $120 - 20 = 100$ **volts.**

So the anode voltage has changed from 70 volts to 100 volts by changing the grid voltage only one volt. If the anode voltage is regarded as the output and the grid the input, the output has changed 30 times the input voltage. The valve, therefore, has a "gain" of 30 times with that particular value of load resistor.

This gain becomes useful if we connect an audio signal to the grid instead of the batteries. For example, if the grid were connected to the microphone in Fig. 1, and a particular sound produced a signal voltage of 0.1 volts from the microphone, this signal would appear at the anode with an amplitude of 3 volts.

Usually one valve does not give sufficient amplification. In the case of the microphone and a single valve, an output voltage of 3 volts would be insufficient to drive a loudspeaker. What we want is another stage of amplification, so clearly we shall have to use another valve. If the gain of the second valve is 30 also, the 3 volt signal from the previous stage will be amplified to 90 volts. The overall gain from the grid of the first valve to the anode of the second is, therefore, 90 divided by 0.1, which is 900.

The gains of valves connected in "cascade" (i.e. one after the other) are multiplied together, in our case 30×30. If necessary, a third stage may be added, but as we shall see later it would be "overloaded" with the 90 volt signal feeding its grid.

Mutual Conductance

In the example given above, it will be noticed that we assumed the anode current would change from 5mA to 2mA when the grid voltage was changed from -1 volt to -2 volts. The amount by which anode current changes for a given change in grid voltage is one of the important features of a valve. It is called the *mutual conductance* of the valve and is usually denoted by the letters *gm.*

The clearest way of illustrating the real meaning of gm is to use a graph.

First look at Fig. 7. The anode of the valve has a meter inserted in its circuit so that the anode current may be measured. The grid voltage may be varied from +3volts to -3 volts with respect to the cathode. Now, if we record the anode current for each grid voltage and plot the results we will obtain a graph as shown in Fig. 8. The vertical axis represents the anode current I_a as read on the meter, I_m, and the horizontal axis the grid voltage indicated on V_m. As the grid becomes more negative, the anode current decreases as explained before. Now as we are dealing with a.c. voltages, for that is what the signal voltages are, we are interested in the *change* of anode current for *changes* in grid voltages. We can see from the graph that the anode current changes 3mA for 1 volt grid change.

The mutual conductance, therefore, is defined as

$$gm = \frac{\text{change in anode current}}{\text{change in grid voltage}} \text{ mA/volt} \qquad (1)$$

In Fig. 8 this is *3mA/volt.*

Mutual conductance is sometimes called the "slope" of the valve. This is because the formula given in (1) above is really a

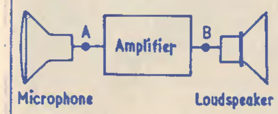


FIG. 1.

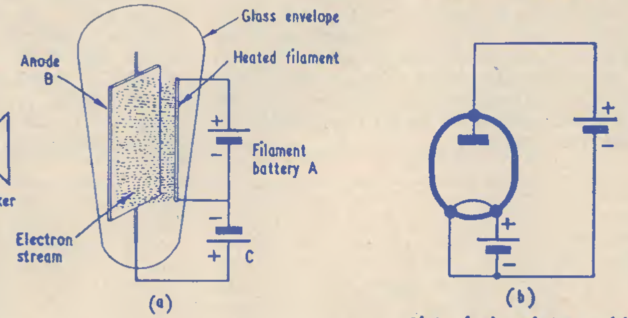


FIG. 2.

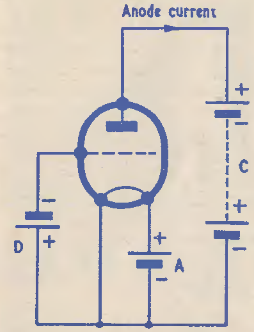


FIG. 3.

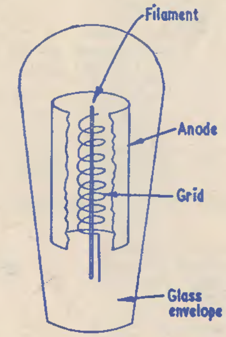


FIG. 4.

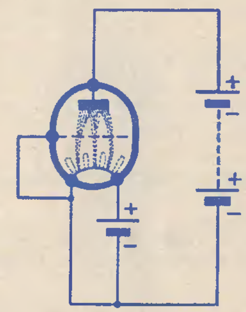


FIG. 5.

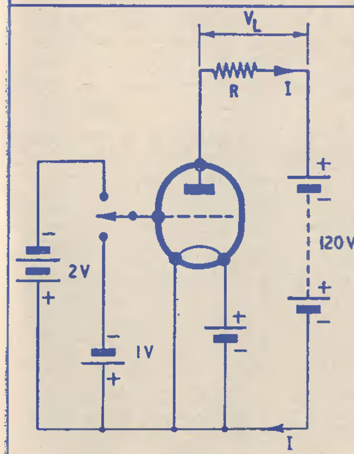


FIG. 6.

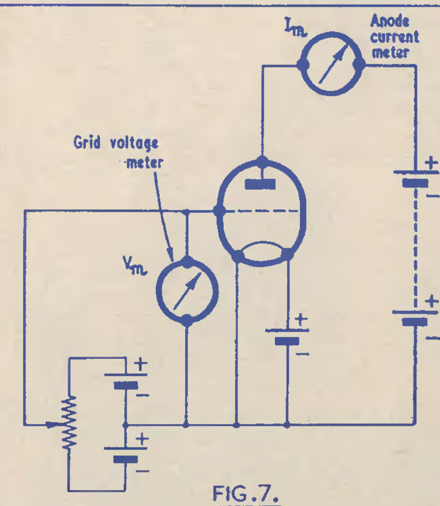


FIG. 7.

G297

measure of the steepness of the line in Fig. 7. For example, if the scales of the axes of the graph are kept the same, the steepness of the line would be greater if the gm were 5mA/volt.

gm is a measure of the valve's performance, but it is not the only one. However, generally the higher the gm the higher the gain obtainable from the valve.

In Fig. 9 the "mutual characteristic," as the curve is called, is used to show how amplification takes place. Here we have the same curve as Fig. 7 and a signal is applied to the grid. This signal (which is the waveform of a perfectly pure sound) swings half a volt either side of −1 volt. As the grid voltage is varied by this signal, the anode current varies in sympathy from 6.5mA to 3.5mA. The curve is perfectly straight over this portion (a "straight" curve is the mathematician's idea, not mine!) so the anode current is directly related to any change in grid voltage. If we were to move the signal to the left and swing it about −2 volts, the curve has become "curved" in the true sense, and the anode current would no longer be a faithful reproduction of the grid voltage, as shown in Fig. 10.

It is clearly important to choose the correct voltage about which to let the signal swing if distortion is to be avoided. This voltage is called "grid bias" voltage.

We shall see next month how the bias voltage may be applied to a practical amplifier, and how valves may be coupled together.

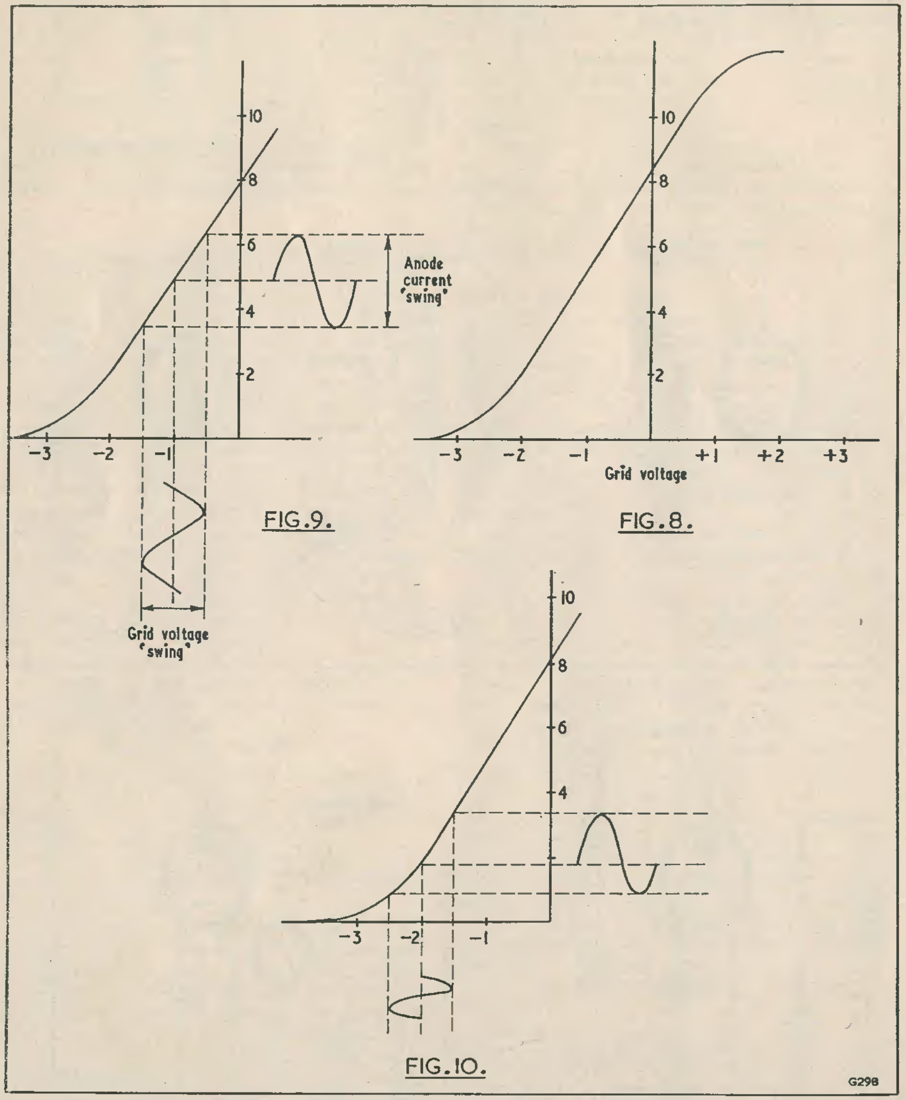


FIG.9.

FIG.8.

FIG.10.

MULLARD 3-VALVE AMPLIFIER, *continued from page 569*

It pays to become the possessor of the best possible loudspeaker your pocket will allow. A large range of loudspeakers is now being offered by a number of reliable manufacturers, at prices to suit most purses. Having a speaker, the next most important job is to see that it is properly housed in a suitable enclosure, usually in some form of cabinet of air-tight construction. The improvement in results obtainable by using a properly designed and made enclosure to suit the particular speaker is such that it amply repays the time and trouble taken in enquiring for details of suitable cabinets. Quite often a good dealer can make recommendations, and perhaps obtain constructional details for those who are interested.

It is important to realise that the furnishings of a room (also its size) have considerable influence on the quality of sound reproduction. The echo effect in an empty, bare room is well known, and only little less so, perhaps, the deadening, muffling effect of heavy curtainings on music, due to undue absorption of the higher frequency tones.

Sometimes it is possible to bring about an improvement in sound quality by moving the loudspeaker to another part of the room—in a corner, for example. It is certainly worth experimenting to achieve the best possible results under any given conditions.

Finally, an inexpensive amplifier such as the one described above, with a good loudspeaker, is an infinitely better proposition than an expensive amplifier with a poor speaker!

CLUB NEWS

Details for insertion in this section should reach us not later than 7th of the month of publication. Insertions are subject to space being available.

CHESTER AND DISTRICT A.R.S.

Meetings are held regularly at the Tarran Hut, Y.M.C.A. Hon. Secretary, D. J. Rickers, GW3HEU, 97 Ruabon Road, Wrexham, Denbighshire.

CAMBRIDGE AND DISTRICT A.R.C.

Meetings are held at the Jolly Waterman, Chesterton Road, Cambridge. Hon. Secretary, F. A. E. Porter, 38 Montague Road, Cambridge.

LEICESTER RADIO SOCIETY

Meetings are held on Mondays at the Holly Bush Hotel, Belgrave Gate, Leicester at 7.30 p.m. Hon. Secretary, J. Tranmer, 4 Grocot Road, Evington, Leicester.

CLIFTON AMATEUR RADIO SOCIETY

Meetings are held every Friday at 7.30 p.m. at the clubrooms at 225 New Cross Road, London S.E.14. Details may be obtained from the Hon. Secretary, C. H. Bullivant, G3DIC, 25 St. Fillans Road, Catford, S.E.6.

BRITISH A.T.C. (Midlands Group)

Details of membership and meetings may be obtained from the Hon. Secretary, F. J. Rawle, G3FHZ, 16 Kings Road, New Oscott, Sutton Coldfield, Birmingham, 23.

EAST KENT RADIO SOCIETY

Particulars of meetings and membership may be obtained from the Hon. Secretary, D. Williams, Llandogo Bridge, Canterbury.

RAVENSBOURNE AMATEUR R.C.

Club stations will be on the air on all bands during the exhibition held at the Downham Mens Evening Institute, evenings only, April 9-14th. Meetings of the club are held every Wednesday evening at Durham Hill School, Downham. Hon. Secretary, J. H. F. Wilson, 4 Station Road, Bromley, Kent.

HASTINGS AND DISTRICT A.R.C.

Meetings are held every Tuesday at 7.30 p.m. and Friday is an additional night for free activity. When the workshop is fully organised, the premises at 22 Middle Street, Hastings will be available at any time to members. Further details from the Hon. Secretary, W. E. Thompson, 8 Coventry Road, St. Leonards-on-Sea, Sussex.

ROMFORD AND DISTRICT A.R.S.

Meetings are held every Tuesday evening at 8.15 p.m. at R.A.F.A. House, 18 Carlton Road, Romford. Hon. Secretary, N. Miller, 55 Kingston Road, Romford.

Radio Miscellany

CENTRE TAP	*talks about*	HOLIDAYS ABROAD R.C. ABROAD T.V. TROUBLES

One or two readers have tentatively enquired whether the Radio Party being organised by Frank Glynn G3GVZ (announced in last month's issue) is restricted to transmitting amateurs or R.S.G.B. members.

I am assured by the organiser that this party is quite unofficial and anyone interested in the I.A.R.U. Conference or the communications side of radio (together with YL's or XYL's) will be welcome. The Conference, which ends on the 16th June, is quite incidental to the trip—although, of course, it provides wide opportunities for meeting amateurs of other nationalities. A number of excursions have been laid on by the Italian amateur radio organisation which offer the advantages of local guidance, ensuring you miss nothing worth while and at the same time effecting a considerable economy.

Stresa, of course, is well known as a wonderful holiday centre for the enjoyment of sunshine, scenery and holiday amenities.

Among the transmitting fraternity, Continental holidays have long been popular, usually to foreign capitals or large towns where local amateurs are more numerous and transport to places of radio or scenic interest is readily available. By the way, I hear there is another small private party off to Denmark in July.

Those whose radio interest is limited to the constructional side are somewhat at a disadvantage compared to the transmitting amateurs. The latter have a long tradition of international friendship, and usually previous radio contacts have been made or can be planned for the future. Nor have they normally much language difficulty (although few G amateurs have any deep knowledge of a second language). The shortcomings on each side can be bridged over by radioese—and a little imagination.

The extensiveness of English speaking is not as widespread throughout Europe as is often supposed. It is a fable lingering on from the days when the English milord found Continental hotel staffs (who had served an "apprenticeship" in London) speaking passable English. Last year, on my return journey, I stopped a night in St. Omer, an industrial town in northern France, where I became involved in a tangle much too complicated for my schoolboy French. Out of the crowds in a main street not a soul could speak English, and I eventually had to ask a gendarme to find an English-speaking resident for me.

Many Continental amateurs, too, will tell you they speak only QSO-English, which you often find to be only too true. To enable you to get off the beaten track it is rewarding to arm oneself with a little knowledge of the grammar and pronunciation, which together with a phrase-book will carry you quite a way. Get to know a few local fellow hobbyists—and there is nothing like a hobby for bringing people together—and your pleasure will be trebled. Even the occasional misunderstandings which will inevitably arise will provide laughs all round as you straighten them out, and will often lead to making further friendships.

The Copies go Round and Round

My recent remarks regarding much-travelled copies of *R.C.* brought to light quite a number of fresh instances of copies that find their way hand-to-hand to the other side of the globe. One reader, Mr. W. J. Peck of Oakington, who built his first crystal set in 1924, sends his copy to his son in Japan as the first leg of its travel. He, too, would like to know where they finish up.

Perhaps even more remarkable is the number of queries received (and sometimes even requested by telephone) from enquirers about receivers which were described in issues of four or five years ago. Do readers save their copies all that time before they start constructing? Or do they build a set and then, years later, when it breaks down, write in instead of using a logical sequence of fault-finding? I always suspect that they are the people who never dream of buying a copy themselves, but who eventually pick a dog-eared copy of 1950 vintage out of the salvage, and then seek to take advantage of a service intended for bona fide readers.

Take Your Choice

Since writing last month of t.v. cabinet design, the importance of accessibility for servicing purposes has been forcibly brought home to me. My stand-by t.v. has developed one of those wretched intermittent faults which has so far completely baffled me. Each time I get it into position for checking, the fault temporarily rights itself. Chasing intermittent troubles on a steam radio is often bad enough, but on a t.v. built all in one piece with the tube arranged along the upper side of the chassis, it is positively maddening. Unless one makes a special support for the tube and arranges the bench so that the chassis can be up-ended, it is impossible to even check voltage points under operating conditions. For the home servicing of such a fault a completely detachable tube assembly, connected by flexible leads, is almost essential.

Now it seems I have three alternatives. One to build a special revolving jig. Two, to build a detachable assembly for the c.r.t., and three, to strip out and re-wire all suspected circuitry. The first is wasteful of time and material as it will probably never be required again. The second seems the most sensible course but I have a horrible feeling I shall never get it all back in the same cabinet. This was "tailored" for the chassis when I finished it—and it fits like the proverbial glove. The third is a drastic remedy servicing engineers are sometimes driven to in despair—the cost of a few resistors and capacitors is a lot less than the cost of the labour for wasted time. One drawback of this ruthless method is that you never really know exactly what the cause of the trouble was. In the making of a televisor the wire ends of the components have to be cut so short that it is often impossible to "dis" them without damage—or damaging something else in the process—so the re-wiring method is not always so comparatively wasteful, even when there is no labour charge.

Cool Work

Often in rebuilds of this nature it is necessary to follow the same procedure as in the original construction and "prefabricate" a small assembly before fitting it to the chassis. When it is a grouping on a tag-board it is fairly straightforward—but when a matter of components only, it is often difficult to hold them in position while soldering. A number of expedients have been suggested to overcome this difficulty—a popular one being the use of spring-loaded clothes pegs. I came across a new one the other day—a raw potato. The free wire ends were pushed into the potato and the components were thus held firmly in position, being kept cool in the bargain!

Streamlined

At school I was taught that radio waves travel at the same speed as light, but it seems they must have been speeded up since that time. On the 25th February, listeners to a Continental station heard a report of a speech by the Chancellor of the Exchequer ten minutes before it took place!

Did 'Ums?

Having had the baby-talk name of walkie-talkie forced upon us by general acceptance, we are now threatened by a worse abomination. A portable man-pack t.v., for transmitting action scene pictures back to a monitor station, is being christened the creepie-peepie!

R.S.G.B. News Bulletin Service

The news service put out by the Radio Society of Great Britain on approximately 3,600 kc/s every Sunday morning is, we understand, at 1000 G.M.T., and no longer at 1100 hours as reported in the February issue.

Technical Forum

The Construction of A.F. Equipment

With the introduction of the long playing record with its increased audio range, and frequency modulation for sound broadcasting, there has been a great deal of increased activity in the construction of audio amplifiers. Most constructors are no longer satisfied with relatively simple two-stage amplifiers but prefer a three or more stage unit, with fully adjustable treble and bass controls and a selection of equalising circuits to suit the response to the type of record to be played. Although there are many complete designs available for such amplifiers which include the fullest constructional details, there are a large number of constructors who deviate from the tested designs to make something which is more in keeping with their particular requirements. There is nothing wrong in doing this, indeed a little pioneering work does much to increase the pleasure derived from our hobby, but there are a number of points which require careful attention if the best results are to be obtained. It is the purpose of this short article to list these possible pitfalls so that they may be avoided.

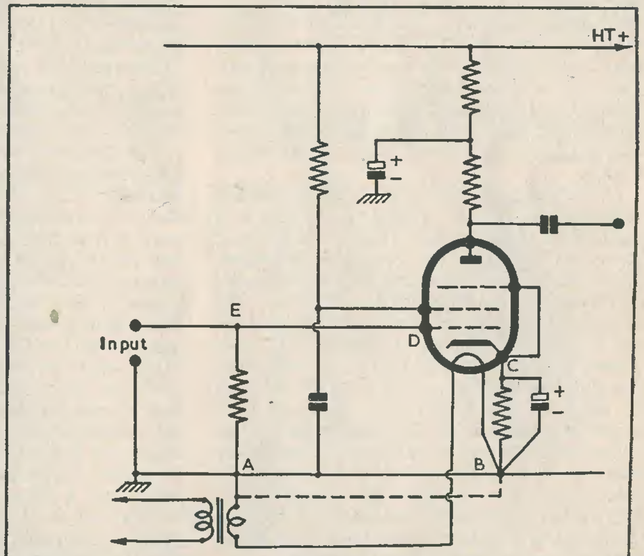
Component Layout

The physical layout of the components in audio equipment has an important bearing on both the stability and hum level, and the general problems involved have been discussed in some detail in previous issues. At this stage, it is sufficient to repeat that the core of the output transformer should be at right angles to that of the mains transformer, and the valves mounted in a straight line. Whilst many amplifier designers do not always observe this latter point, the "in line" layout is very safe, as it keeps the input and output leads as far apart as possible. Having decided upon a satisfactory layout for the major components, more careful consideration has to be given to the lead routing, and in particular to earthing points. The popular misconception that earthing leads must be joined to the chassis by the shortest possible route can often lead to trouble due to the interaction of chassis currents. The chassis must not be regarded as a common earth plate whose surface is at a uniform potential because an earth return current may cause a small difference of voltage to appear between two points. Consider, for example, the single amplifier stage shown in Fig. 1. The signal appearing across the input terminals is applied to the grid and cathode of the valve via the circuit ABCDE. That part of the signal which appears between the grid and cathode of the valve is the only part which is effective, and in reaching the valve, it may easily have picked up a hum voltage from across CB or AB. It will be noted that the connection between A and B is common to both the heater circuit and the signal circuit, and may be termed a "common return path." This path obviously has a finite resistance, and the a.c. heater current flowing in this resistance produces a small voltage which appears directly in the signal circuit. In a high gain stage, a few microvolts from the heater return path can produce havoc with the hum level. To cure this particular case of hum, the transformer earth return lead should be taken directly to point B as indicated by the dotted line. The lead AB may not in fact be a length of wire but a common path in the metal chassis. Earth return currents which are particularly worthy of attention are those in the a.c. heater circuit and earthing leads of the smoothing capacitors. These capacitors may easily carry a.c. currents which are five to six times in excess of the total h.t. drain. The valve heaters are best fed by two leads twisted together, the supply being earthed at a point near the first stage. In twisting the supply leads, the stray magnetic field produced by them is reduced, thus cutting down the risk of induced hum.

By appreciating the method by which return currents can interact to produce hum or instability much can be done to position earthing points to prevent trouble. The best method, however, is to use a separate insulated earthing point for each stage, and to this point are taken the grid, cathode and decoupling capacitor leads associated with that stage. The earthing points are then joined together by a length of 18 s.w.g. tinned copper wire which is finally earthed to the chassis at the input socket. When laying out an amplifier using this arrangement, it should be remembered that it may be necessary to isolate the metal cans of smoothing electrolytics.

Feedback

Negative feedback correctly applied can level the frequency response, improve the linearity of the amplifier, and reduce its output resistance, thereby increasing the damping on the speaker. To realise these advantages it is essential that the feedback is applied only over that part of the amplifier in which there is negligible phase shift. Failure to observe this can result in a peaky response, or even instability, and this has often led to very disappointing results being obtained when a feedback circuit is added to an existing amplifier. Components which cause phase shift must possess either inductance or capacitance, and attention must thus be directed towards coupling capacitors or coupling transformers. When feedback is taken from the secondary of the output transformer, this component must be beyond reproach. In particular, the leakage inductance must be low and the primary inductance high, whilst the core should be of generous proportions to avoid any tendency towards saturation. The requirements are usually found only in the more expensive components; remember, an amplifier is only as good as its output transformer. Interstage transformers are seldom, if ever, used these days because of their tendency to produce phase shift and a falling frequency characteristic. Instead, R.C. coupling is employed and, providing the capacitor has adequate capacitance, both these disadvantages are overcome. A tone control circuit usually consists of a combination of R.C. and sometimes L, the time constants selected being of such values that the desired reshaping of the frequency response curve is obtained. It is inherent in the system, however, that this characteristic is only obtainable at the expense of considerable phase shift and because of this the tone control circuit should not be included within the feedback loop. If good high fidelity is the target, this point must be observed, as phase shift within the loop can cause bad transient response and parasitic oscillation in the higher audio frequencies. Many designers prefer to employ two or more separate feedback loops in amplifiers having more than three stages. This limits the degree of phase shift within each loop.



E300

Fig. 1
Showing a common earth return path in a simple RC amplifier stage

Signal Levels

It is useful to recollect that the stages which handle the lower signal levels are those which are most susceptible to hum and noise. Careful layout and adequate smoothing and decoupling is necessary; it is also good practice to employ high stability 1 watt anode load resistors to reduce thermal agitation noise.

Avoid overloading the stages which carry the higher signal levels, as this is a prolific cause of intermodulation distortion. Knowing the grid signal voltage required for the output valves to provide full output, it is a relatively simple matter to work back and calculate the signal levels at the previous stages. To determine if a valve is operating within its signal handling capacity the very useful tables published by the valve manufacturers should be consulted. These tables give values for load and bias resistors, together with input and output signal levels for stated values of distortion.

It is hoped to deal with the points mentioned above, individually, and in more detail, in subsequent issues.

MICROAMP to MICROGRAM

by **O. J. RUSSELL,** *B.Sc.,* **G3BHJ**

FOLLOWING UPON THE DESCRIPTION OF THE "Microamp" miniature high fidelity amplifier (Sept. '55 issue), some further details and information on a small speaker enclosure may be of interest to those seeking an inexpensive introduction to high fidelity.

Firstly, there are those who would like to "beef up the bass control." Where a greater control over the bass register is required, the bass boost control circuit may be modified in accordance with Fig. 1. This will give a wider range between the full bass and "normal bass" positions. Provided the speaker has a reasonable h.f. response, additional top boosting should not be required. However, top boost can be achieved by shunting capacitors across the feedback path and earth, as shown in Fig. 2.

In the original circuit, a 0.01μF condenser was shunted directly across the primary of the output transformer. This is a stabilising measure designed to prevent instability. While it may be sometimes omitted, its inclusion is recommended. Due to the negative feedback, no reduction of audible top occurs. However, if desired, the condenser may be replaced with a lower value; say, 0.005 or 0.002μF. Too great a reduction in value of the stabilising condenser may result in instability in the supersonic region of the audio spectrum. While such instability may not be directly audible, it may seriously deteriorate the quality of reproduction. Accordingly, one modification is to place a resistance of 2.2kΩ in series with the 0.01 or 0.005μF condenser as shown in Fig. 3.

Readers wishing to use alternative valves, or miniature valves, may note that provided the bias resistors are suitably changed, many other valves of roughly similar characteristics may be substituted for the 6J7 and the 6V6. Thus the 6BW6 is a direct replacement for the 6V6, and this miniature valve may be used in the output stage without circuit modification. Similarly, miniature amplifying pentodes such as the 6BR7 may be used in the preamplifier stage provided that the bias and screen resistors are suitably adjusted.

With the circuit as previously shown, the sensitivity has been perfectly adequate for reproduction of both 78 and LP records when using a crystal pick-up. Where slightly more gain is needed, this can be achieved—at the cost of reduced feedback—by increasing the series resistor in the feedback chain. If a 15 ohm speaker is used in place of the 5 ohm unit, the feedback resistor must be increased if the degree of feedback is not to be increased with the higher impedance. This, of course, assumes that the output transformer ratio is selected to match 15 ohms to the 6V6 output. In this case, the series resistor should be increased to 5kΩ. Fig. 4 shows the position of the feedback resistor. Reducing the value of this resistor *increases* feedback and *reduces* gain. An increase of the resistor decreases feedback and correspondingly increases gain.

The amplifier was intended as a low cost exercise in reasonable high fidelity. The manufacturers of high fidelity equipment assure us that the loudspeaker and enclosure are "a vital link" in the high fidelity chain, and reinforce this by quoting anything up to some £150 for a loudspeaker enclosure system. This naturally does not encourage the impecunious seeker after high fidelity, nor for that matter the far from impecunious. While this is not intended to detract from the merits of these elaborate speaker enclosures, it does suggest that the Hi-Fi coat must be cut according to one's pocket. Just as no claims for outdoing the Williamson are made for the miniature amplifier, while still providing a very good approach to high fidelity, so it is interesting to consider a speaker enclosure of simple design that is capable of good performance.

If we are prepared to forego the pleasure of hearing 32 c/s tones reproduced with no attenuation, but are prepared to accept a reasonable standard of fidelity, the requirements for a speaker enclosure capable of giving a firm bass response may be drastically reduced. First, it should be noted that the size of a vented speaker enclosure depends both upon the bass resonant frequency of the speaker *and* upon the size of the speaker cone. It might be noted that the G.E.C. metal cone speaker is housed in a cabinet considerably smaller than the usual vented enclosure. This is because the speaker cone is relatively small, and also because the bass resonance is around 55 c/s rather than 30 c/s. Hence the G.E.C. designed speaker enclosure is definitely much more compact than the usual enclosure for, say, a 12in-speaker with a 30 c/s bass resonance.

The usual "average receiver" speakers often have cone resonances of from 80 c/s to 120 c/s, so that a very compact enclosure becomes feasible. To illustrate this, Fig. 5 shows the dimensions adopted by the author to house both the amplifier with power pack and a speaker with a 5"-in diameter cone. This was not a super high fidelity unit, but was a surplus speaker and transformer acquired for a few shillings. However, this type of speaker similar to the usual commercial receiver speakers was chosen because the small cone size and the relatively high cone resonance frequency enable a compact enclosure to be made.

The open frame of the enclosure and the speaker panel were made from ¾in timber. For test purposes the back and the space below the speaker panel were closed with hardboard. While it was expected that damping layers would have to be applied, or that variations in the size of slot or enclosed volume would have to be experimented with, adequate reproduction with a firm level bass was obtained straightaway.

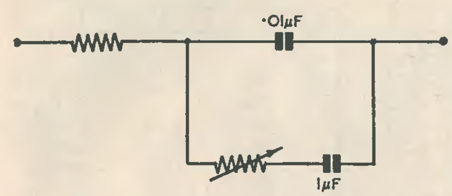


Fig.1
Modified value of feedback condensers to give a greater degree of bass boost

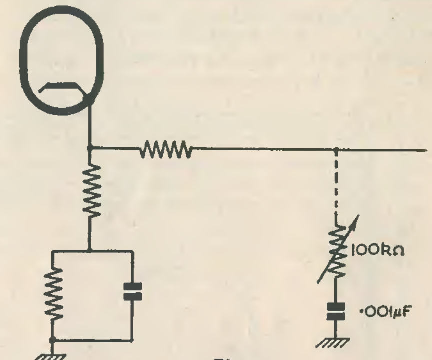


Fig.2
Additional top boost can be obtained by the 100kΩ resistor & the ·001µF condenser shunted across the feedback loop

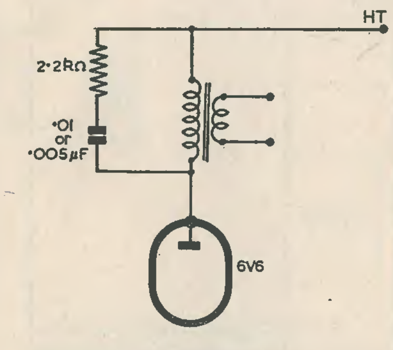


Fig.3
A 2·2kΩ resistor may be added in series with the stabilising condenser shunted across the output transformer primary

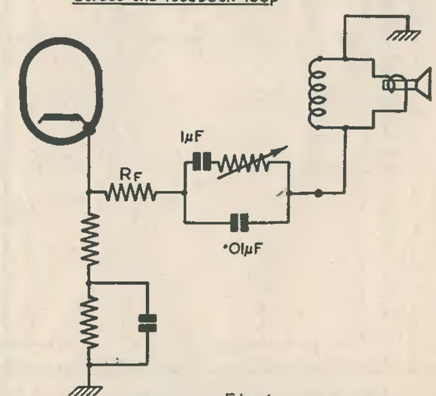


Fig.4
The feedback resistor R_F may be varied as explained in the text

E228

It should be noted, of course, that a 5in cone will radiate the upper register well, and in fact a certain amount of beaming of the uppermost register was apparent. Inclined strips of wood in front of the cone (Fig. 6) would assist in diffusing the higher notes. In fact, the faint hiss on LP records with full top was noticeably confined to a fairly narrow beam. The cone at present is beamed on the author's armchair. However, it was the provision of adequate and level bass which was the primary reason for the construction of the enclosure. It was gratifying therefore to find that the bass response was full, firm and devoid of obvious resonances. For such a simple and inexpensive device this was felt to be satisfactory indeed.

With a commercial playing desk close to the enclosure, acoustic l.f. feedback occurred due to the well-sustained bass register. This was cured by moving the playing desk further away. The feedback was at approximately 100 c/s, showing that good bass output was obtained. The bass register can be extended a little further by placing the unit on the floor finger tips. In this case it may be found necessary to apply a little internal damping, either by partial felt linings or by hanging felt in the middle of the enclosure. Furthermore, some adjustment of internal dimensions may be necessary in individual cases.

It should be clearly understood that no lavish claims are made for the enclosure. It is not intended to compete with, say, a Klipschorn or a Guy Fountain enclosure, but is intended to house a small diameter 5-in cone type of speaker rather than a 12-in speaker. It is, in fact, intended to provide good results from the simplest and least costly speaker.

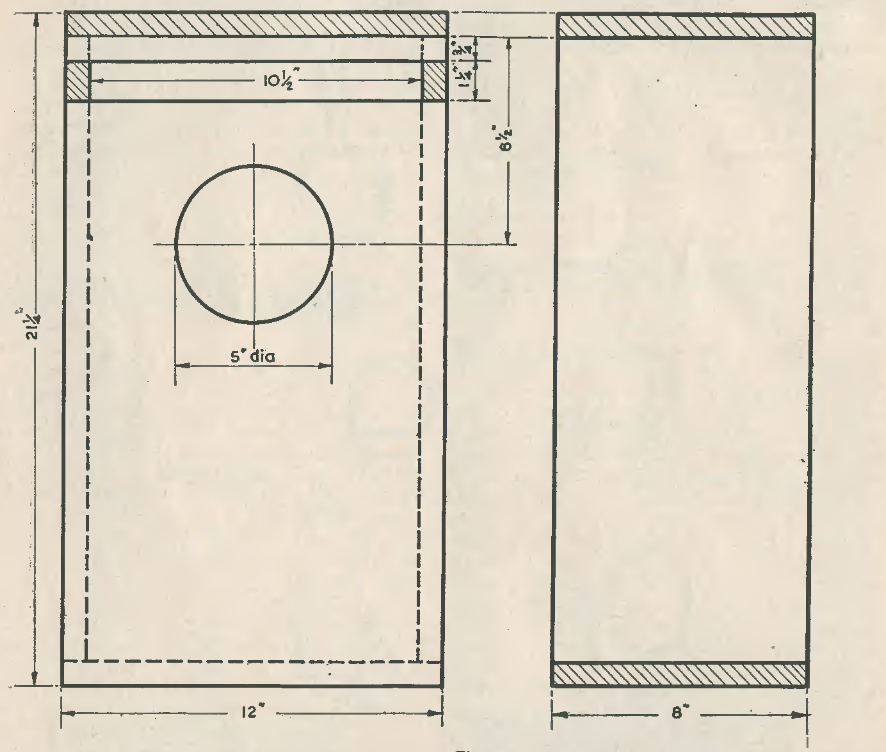


Fig. 5
Vented enclosure suitable for 5" cone speakers of the usual "broadcast receiver" design
Material: ¾" timber
Slot: 10½" x 1¼"
E229

in the corner between two walls, with the speaker facing into the corner of the room.

While in the above unit the back and front were closed in by hardboard, in a permanent version the hardboard should be replaced by solid timber of ⅜-in thickness, as the thinner hardboard is violently vibrated in the bass region; this may be felt by pressing with the

The Microgram amplifier will, of course, be suitable for larger speakers, provided they are housed in suitable enclosures. However, in all cases solidly constructed enclosures are necessary. If an output transformer somewhat larger than the usual "matchbox" type is used with the Microgram, the bass register should be adequate.

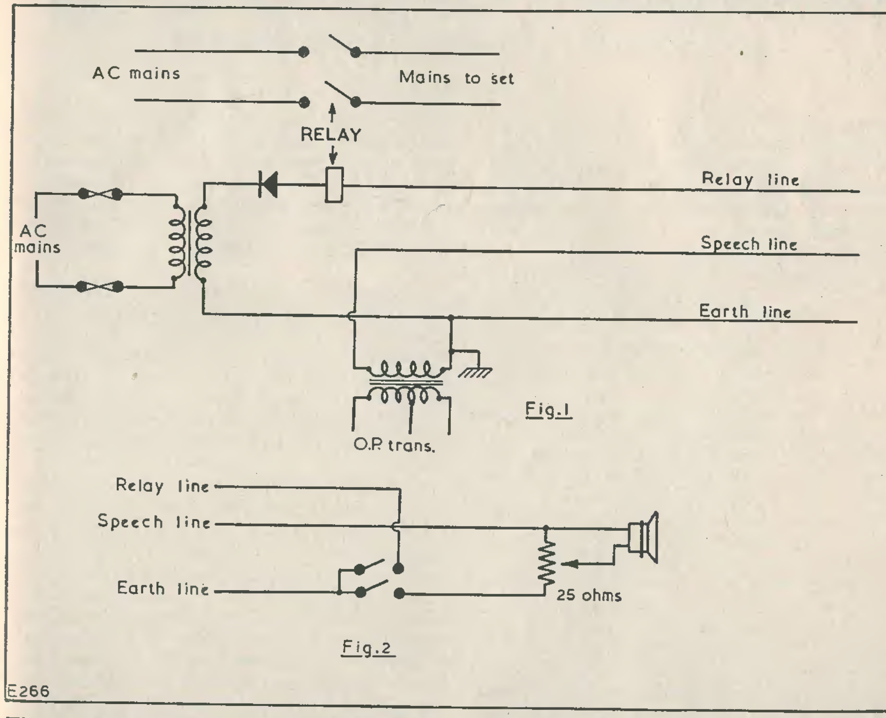
REMOTE SWITCHING OF THE DOMESTIC RECEIVER

by R. J. DONALD, G3DJD

Many people have extension speakers attached to their domestic radios, in the kitchen or bedrooms. One often finds these fitted with a volume control, but it is not difficult or expensive to provide a means of switching the radio on and off from each speaker. Some years ago one large speaker manufacturer produced an accessory called a "long arm" which worked on a ratchet principle. The writer has for some years used a post office type relay for the purpose with excellent results.

Three wires are run round the house to each room. These should be colour coded and can be known as the "earth line," "speech line" and "relay line." One side of the output transformer must be earthed to *true* earth (i.e.—*not* the chassis of a universal receiver). Now if we at any point can connect the relay line to the earth line, the relay will close, and if we open this circuit, the relay will open. Fig. 1 shows the arrangement. Having achieved this, the relay can be used to make and break the input circuit to the receiver. Light contacts are suitable for normal receivers used on a.c. mains and double-pole switching is advisable. With universal receivers, especially on d.c. mains, heavy contacts and spark suppressors consisting of capacitors of around 0.1μF and 100 ohms in series fitted across the contacts are advisable for long service.

Fig. 2 shows the arrangement used at each speaker (including the one on the receiver itself). The switch can be a d.p.s.t. tumbler or a rotary two-pole on/off. The volume control can be separate. If desired a single



The other side of the output transformer goes to the speech line. A source of current—battery or from the mains via a transformer and rectifier—has one side earthed to the earth line and the other connected to one side of the coil of a suitable relay. The other side of this coil is connected to the "relay line." control will do in which case the switch should be a three-pole, five- or six-way rotary switch. This can be wired to give an "off" position and a number of volume levels by means of selected fixed resistors.

In practice, the volume control on the receiver should be set so that the output is greater than will be required at any speaker, and further adjustments made on the speaker volume controls. The ladies of the house may have to be instructed with care not to "cross the controls" by turning up the receiver control and turning down the speaker controls. It is possible by this means to produce low level music with horrible distortion!

The actual voltage and current required will depend upon the relay used. If 9 volts can be obtained from the domestic front door bell transformer, it can be used with a relay of 250 to 500 ohms if the contact springs are carefully set. The current will be only a few milliamps and a 75mA rectifier will be adequate. On the other hand, a couple of 4.5V bell batteries will give several months service.

Where it is possible to use negative feedback on the audio amplifier stages of the receiver and especially when the method shown in Fig. 1 is used, there will be no noticeable drop in volume level on one speaker when others are switched on. Increased speakers in parallel simply reduce the load on the speaker transformer secondary and therefore reduce the negative feedback voltage to the earlier stage, resulting in an apparent compensating increase in gain.

The luxury of being able to start listening to that late night play or programme of music, downstairs, hear the middle of it in the bath, and the last of it tucked in bed with only the need to extend a hand and flick a switch to put the receiver off downstairs, is certain to make the radio enthusiast very popular in the family. Needless to say, however, if this practice is to be encouraged, a first-class job must be made of all insulation and there should be no trailing lengths of flex with mains voltage left on them when the gear is nominally off.

DESIGN CHARTS FOR CONSTRUCTORS

No. 5 WAVELENGTH-TO-FREQUENCY CONVERSION

by HUGH GUY

THIS MONTH'S CHART IS COMPARATIVELY straightforward. It is based on the well-known relationship between the frequency of oscillation and the wavelength of a radio wave, their product being the velocity of propagation of the radio wave through free space or the "æther."

This relationship is given in the formula:

$$\lambda = \frac{300,000,000}{f}$$

where λ is the wavelength in metres and f is the frequency in cycles per second.

When one is dealing with the upper bands one usually talks in terms of frequencies; the abbreviation "V.H.F." is now an everyday word and proves the point admirably. At the low end of the band, radio waves are spoken of in terms of their wavelengths; the B.B.C. refers to its long-wave transmission of the Light programme as being 1,500 metres.

This confusion in the method of measuring is heightened when we remember that at "very high frequencies" we usually require to know the "wavelength" of the transmission in question in order to produce an aerial of the correct length. Furthermore, having obtained this wavelength in metres we then have invariably to convert this measure to feet and inches, in order to conform to the peculiar English system of units. Of course, this last step is obviated if we possess a continental rule or tape measure, but lack of consistency in the method of identifying radio waves prevents an easy way out.

The chart accompanying this article simplifies the task to a certain extent. The problem of conversion is by no means a difficult one, of course, but it is very easy to make a mistake when calculating due to the number of noughts following the principal digit, and this possibility is removed with the chart.

It covers the range of frequencies from 300 kc/s to 300 Mc/s, in four stages. The information could have been presented in one continuous graph, but this would have detracted from the accuracy of the results obtainable. Four separate scales are therefore given, any vertical scale being read in conjunction with its corresponding horizontal scale.

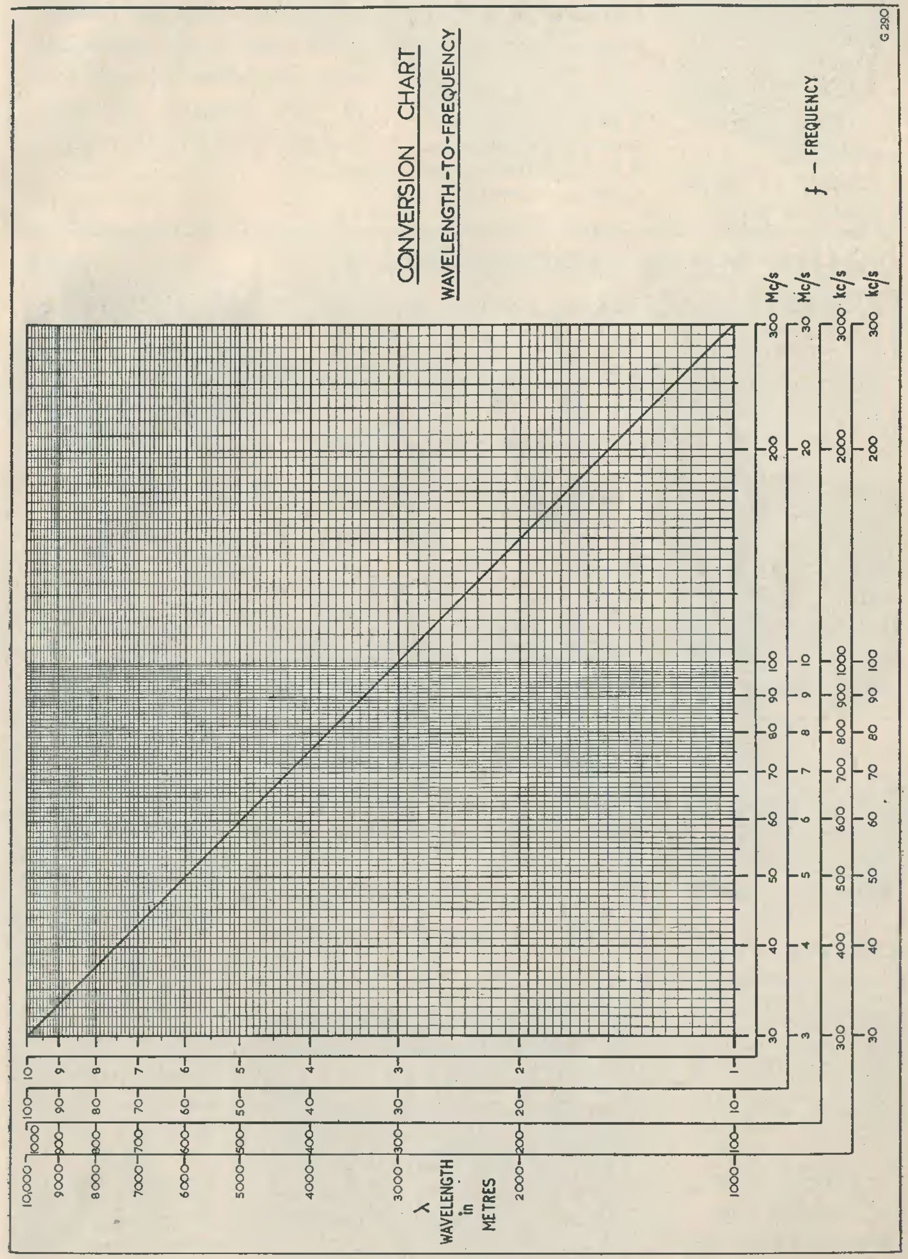
The vertical scales give the wavelength in metres and cover the range 1 metre to 10,000 metres in the long-wave band. Two simple examples will illustrate its use:

Example 1: What frequency does 450 metres correspond to? The 450 mark is located on the wavelength (vertical) scale and is found on the second scale. The horizontal projection of this line cuts the key diagonal line at a point corresponding to 665 kc/s on the second frequency (horizontal) scale.

A check of the accuracy of this result shows that it is less than ½% out.

Example 2: What wavelength coverage does a tunable circuit give if its frequency coverage is 20 Mc/s to 60 Mc/s? The frequency calibration corresponding to 20 Mc/s is on the third scale and is seen to produce a reading on the appropriate vertical scale of 15 metres. Similarly, that of 60 Mc/s is on the fourth or innermost scale and its corresponding wavelength reading gives 5 metres. The wavelength coverage provided by this circuit is, therefore, 5 to 15 metres.

In the next few months' charts, information will be given on the design of circuits to oscillate at a predetermined frequency. These charts will cover the A.F. to the V.H.F. range and will all be based on the use of this month's chart.



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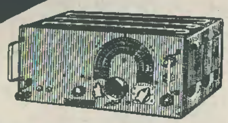

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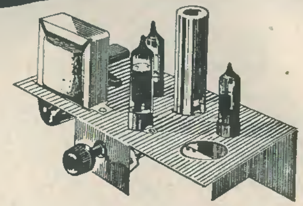

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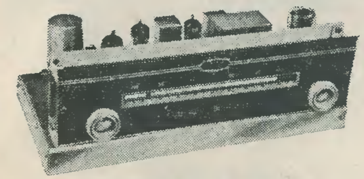

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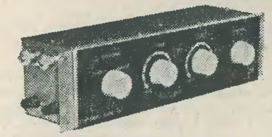

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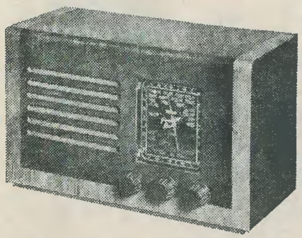

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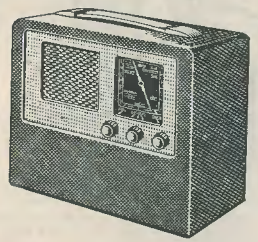

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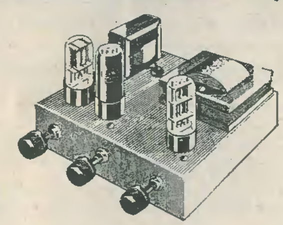

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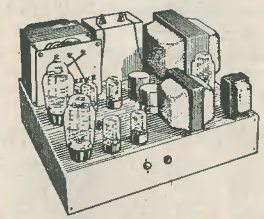

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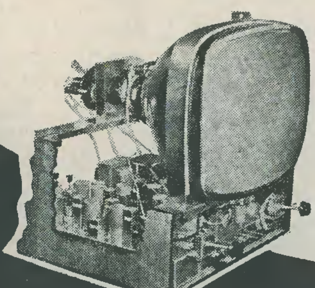

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(50 yards only from Tottenham Court Road Tube)

Monday-Friday 9-6 pm
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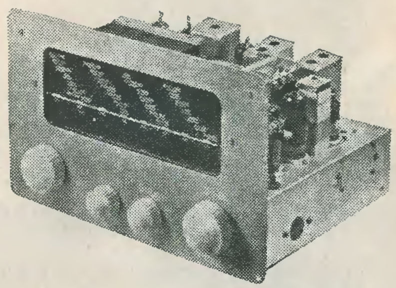
London's largest stock of FM components

Following on the enormous success of the **Jason FM Tuner**, we can now offer the complete kit for the **AM/FM Chassis** described in this and last month's issues of *The Radio Constructor*. An individually priced parts list is available on application, but a complete kit can be purchased complete with output stage at **£15 5s. 0d.** Also as above but without components for output stage, at **£13 19s. 6d.** Both plus 3/6 p. and p. Both kits are complete down to last nut and bolt, all valves including latest **DM70 Magic Eye**



Jason Chassis Assembly complete **£3 18 0**
Jason I.F. and Coil Set complete **£2 17 9**

Valve Set complete, comprising three EF80, ECH81, 6BA6, EABC80, 6AQ5, EZ80 and DM70 at special inclusive price of **82/6**, or set of valves less 6AQ5 price **75/–**

N.B.—This chassis is for FM and medium waves only

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VALVES
NEW TESTED AND GUARANTEED

1R5	7/6	6J5G	5/6	AZ31	10/6	EF37A	14/6
1S5	7/6	6J5GT	6/6	BL63	10/6	EF39	5/6
1T4	7/6	6K7G	6/–	DF91	7/6	EF55	9/6
3S4	7/6	6K8	8/6	DK91	7/6	EF80	10/–
3V4	7/6	6K8G	8/–	DAF91	7/6	EF85	10/6
5U4G	8/6	6K8GT	8/6	DL92	7/6	EF91	7/6
5Z4G	8/6	6L6G	9/6	DL94	7/6	EF92	4/9
6AG5	6/9	6Q7GT	8/6	DK92	7/6	EK32	8/6
6AM6	7/6	6SN7GT	8/6	DK96	9/–	EL32	7/6
6AL5	6/6	6SL7GT	8/–	EA50	1/6	EL84	11/–
6AT6	8/–	6SS7	6/6	EB34	5/6	EM34	12/6
6BE6	8/–	6V6G	7/6	EB91	6/6	EY51	11/6
6BW6	8/–	6V6GT	7/6	EBC33	8/6	EZ35	8/–
6B8	7/6	6X4	8/–	EBF80	10/6	KT33C	9/6
6B8G	7/6	6X5GT	7/6	ECC81	10/6	KT66	11/6
6BA6	8/6	12AT7	9/–	ECH35	9/6	PL81	10/6
6BR7	8/6	12AU7	9/–	ECH81	10/6	PL82	10/6
6SA7	8/–	12AX7	8/6	ECH42	11/6	UCH42	11/6
6F6G	8/–	58	7/6	ECL80	10/6	PCC84	11/6
6F8G	8/6	807	6/9	EF22	7/6	X41	12/6
6G6G	4/9	5763	7/6	EF36	7/6	X65	10/6

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

Volume Controls. All values, long spindle. L/S **3/–**, SP **4/–**, DP **4/6**, ext. spkr. control, **3/–**

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Coaxial Cable. 75 ohm ¼" stranded, **8d.** yd; semi-air spaced, **9d.** yd; screened cable single and twin, **9d.** yd
Coaxial Plugs and Sockets 1/– each
Valveholders. 4, 5, 7 pin English and U.S.A. B7G, B9A 1.0 Mc, B8G, **9d.** each; B7G, B9A with screening can, **1/6**
2-Gang Condensers, .0005 small size, **6/6**
I.F. Transformers, 465 kc. small size, **9/6** pair
Capacitors, small mica, 5% 1pF to 100pF, **8d.**; 120pF to 1,000pF, **9d.**
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Recording Tape. 1,200ft on standard plastic spools, **17/6**
Resistors, ¼ and ½W, insulated, **4d.** and **6d.**; 1W, **8d.**; 6W W.W., **1/–**; 10W, **2/–**
Electrolytics. Wire ends. 25/25V, **1/6**; 50/50V, **2/–**; 12/50V, **9d.**; 8/450V, **2/–**; 16/450V, **2/9**; 32/450V, **4/–**; 8+16/450V, **4/6**; can types: 16/450V, **3/6**; 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, **5/6**
Solder, Multicore, 4d. yd

Band III Converter Kits for Midland Litchfield Transmitter. Complete kit of parts, including ready wound coils, two EF80 valves, drilled chassis and wiring diagram. For a.c. mains 200-250V. **£3 10s. 0d.**, p. and p. 1/6
As above less power pack components. Power required, 200V 20mA, 6.3V 0.6A. **£2 5s. 0d.**, p. and p. 1/–
Teletron Band III Coil Set. Mk I **15/–**; Mk II **17/6**; Osmor Coil Set **17/6**
Aerials. Band I from **13/6**; Band II **17/6**; Band III **6/6**

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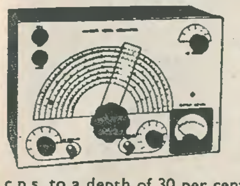
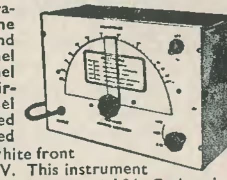
COMPLETELY BUILT SIGNAL GENERATOR



Coverage 120 Kc/s-320 Kc/s, 300 Kc/s-900 Kc/s, 900 Kc/s-2.75 Mc/s, 2.75 Mc/s-8.5 Mc/s, 8 Mc/s-28 Mc/s, 16 Mc/s-56 Mc/s, 24 Mc/s-84 Mc/s. Metal case 10" x 6¾" x 4¼". Size of scale 6½" x 3¼". 2 valves and rectifier. AC mains 230-250V. Internal modulation of 400 c.p.s. to a depth of 30 per cent, modulated or unmodulated RF output continuously variable 100 milli-volts. CW and mod. switch, variable AF output and moving coil output meter. Black crackle-finished case and white panel. Accuracy ±2%. **£4 19 6** or **34/–** deposit and 3 monthly payments **25/–**. P. and p. 4/6 extra

PATTERN GENERATOR



40-70 Mc/s direct calibration, checks frame and line timebase, frequency and linearity, vision channel alignment, sound channel and sound rejection circuits and vision channel band width. Silver-plated coils, black crackle-finished case 10" x 6¾" x 4¾" and white front panel. AC mains 200/250V. This instrument will align any TV receiver, accuracy ±1% Cash price. **£3 19 6** or **29/–** deposit and 3 monthly payments of **£1.** P. and p. 4/6 extra

←Both generators guaranteed for 12 months ↑

BAND III CONVERTER KIT

comprising 5 channel tuner, mains transformer, metal rectifier, electrolytic, 2 valves, 12AT7 and EF80, and all necessary components for a.c. mains operation. Complete with conversion data

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for the new commercial stations, complete with 2 valves. Frequency can be set to any channel within the 186-196 Mc/s band. IF will work into any existing TV receiver between 42-68 Mc/s. Input arranged for 80 ohm feeder. EF80 as RF amplifier, ECC81 as local oscillator and mixer. The gain of the first stage RF amplifier 10db. Required power supply of 200 DC at 25mA, 6.3V AC at 0.6 amp. Input filter ensuring freedom from unwanted signals. Simple adjustments only, no instruments required for trimming. Will work into any TRF or superhet. Incorporating band switch and wire-wound gain control. Fully screened in black crackle-finished case, size 5¾" long, 3¾" wide, max. overall height 4½", **£2 19 6**, p. & p. 2/6. As above with built-in power supply, **£3 19 6**, p. & p. 2/6. AC mains 200/250V

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3-speed automatic changer

Ten records, turnover crystal head, brand new current model. AC mains 100/250V (list price £14 10 0). **£8 19 6**, p. and p. 5/–

Used Metal Rectifier, 230V 50mA, **3/6**; gang with trimmers, **6/6**; M. & L. T.R.F. coils, **5/–**; 3 Govt. valves, 3 v/h and circuit, **4/6**; heater trans., **6/–**; volume control with switch, **3/6**; wave-change switch, **2/–**; 32 x 32mfd., **4/–**; bias condenser, **1/–**; resistor kit, **2/–**; condenser kit, **4/–**
Line and EHT Transformer, 9kV. Ferrocart core. EY51 heater winding, complete with scan coils and frame output transformer and line and width control. P. and p. 3/–, **35/–**
As above but complete with line and frame blocking transformers, 4 henry 250mA choke, 100 mfd and 150 mfd 350 wkg 380mA AC ripple. P. and p. 3/–. **£2 9 6**
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USED Metal Rectifier, 250V 150mA, **6/6**
Combined 12" Mask and Escutcheon Perspex. New aspect, edged in brown. Fits on front of cabinet, **12/6.** As above for 15" tubes, **17/6**
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20-watt AC or DC 200/250V. Fluorescent kit, comprising trough in white stove enamel, 2 tube holders, starter, starter-holder and barreter, p. & p. 1/6, **12/6**
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1,200ft High Impedance Recording Tape on aluminium spool. **12/6**, post paid
Valveholders, moulded octal Mazda and loctal, **7d.** each. Paxolin, octal Mazda and loctal, **4d.** each Moulded B7G, B8A and B9A, **7d.** each. B7G and B9A moulded with screening can, **1/6** each

32mfd, 350 wkg	2/–	16mfd, 500 wkg	3/3
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16 x 8mfd, 500 wkg	4/6	100+200mfd, 275 wkg	7/6
16 x 16mfd, 500 wkg	5/9	16+16mfd, 350 wkg	3/3
16 x 16mfd, 450 wkg	3/9	50mfd, 180 wkg	1/9
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Complete kit of parts for "Teletron" Converter. Including 2-EF80 and chassis and wiring diagram. Voltage required 200V 30mA, 6.3V 0.6A ... 48/6 plus 2/- p.p.
Or assembled and tested... ... 67/6 plus 2/- p.p.
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The Unit complete with power supply. Tested and ready to plug in ... 97/6

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Teletron Mk 2 coil set		17/6
Additional resistors	each	3d.
Additional condensers	each	9d.
Valves, type PCF80 (tax paid)		12/6
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Or the complete Mk 2 Kit at 59/6

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TYPE FT243 fundamental frequencies 2 pin ½" spacing. **200** types in the following frequencies: 5675 Kc/s to 8650 Kc/s (in steps of 25 Kc/s); 5706 Kc/s to 8340 Kc/s (in steps of 33.333 Kc/s.) All brand new **10/-** each. **Special price for complete sets of 80 or 120.** Above are suitable for regrinding.

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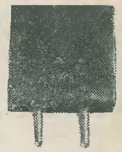

INDICATOR UNIT TYPE 182A

Unit contains VCR517 Cathode Ray 6" tube, complete with Mu-metal screen, 3 EF50, 4 SP61 and 1 5U4G valves, 9 wire-wound volume controls and quantity of resistors and condensers. Offered BRAND NEW (less relay) at **67/6** plus 7/6 carr. *Radio Constructor* 'scope circuit included.

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VCR139A. 2½" C/R Tube. Brand new in original cartons (carr. free)	£1	15	0
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FOR SALE R1155 receiver, power pack and output stage. Little used and complete in original packing. £8 10s. 0d. Cross, 36 Whitehall, London, S.W.1.

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FOR SALE 348, "*Electronic Engineer*" time base, vision, sound strips, mains trans., Holme Moss, 12" magnifier and mask. 2-5CP1 with 4kV trans., 2×2 rectifiers, 100 valves 6.3 and 12V heaters. Offers. Box No. E108.

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(continued on page 599)

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A superb 12 valve 3-band receiver covering 150-1,500 kc/s, i.f. frequency 112 kc/s. Valve line-up: 6K7 1st and 2nd R.F., 6L7 mixer, 6J5 Osc, 6K7 I.F. amp., 6B8 1st and 2nd det. and a.v.c., 6J5 b.f.o., 6F6 audio output, compass mod. 6N7, audio oscillator 6N7, loop amp. 6K7, compass output 6K7. 28 volt supply to motor generator which can be easily changed to 12 volts (details available). Circuits, etc., free with each unit. **The Perfect Car Radio.** Size 15¾" x 11¾" x 6". Power supply 6.3V and 250V. Price **£3 10 0** *plus 7/6 packing and carriage.*

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POWER PACK Type 173. 12 to 24 volt l.t. input. 120V 60mA output. Fully smoothed, size 10½" x 6" x 3". Containing **two** 120 volt 60mA selenium rectifiers. One V.S.110 voltage stabiliser; 12 volt vibrator and transformer, chokes and condensers, **12/6** post paid

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"SUPER" R/G CHASSIS, £6 17s. 6d., with speaker, 8" p.m. 4 w/band 5 valve s/het, famous manfr. Complete with octal valves, 4 controls. Dial 5½" x 9" Carr. 4/6

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(continued from page 597)

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(continued on page 600)

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(*continued from page 599*)

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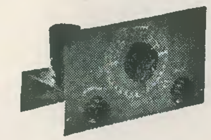

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