Published in Great Britain by the Proprietors and Publishers
Data Publications Ltd 57 Maida Vale London W9
Printed by A. Quick & Co. (Printers) Ltd 125 High Holborn London WC1 England *also at* Clacton-on-Sea
Obtainable abroad through the following Collets Subscription Service Continental Publishers & Distributors Ltd William Dawson & Sons Ltd *Australia and New Zealand* Gordon & Gotch Ltd *South Africa* Central News Agency *Holland* "Radio Electronica"
Registered for transmission by Magazine Post to Canada (including Newfoundland)

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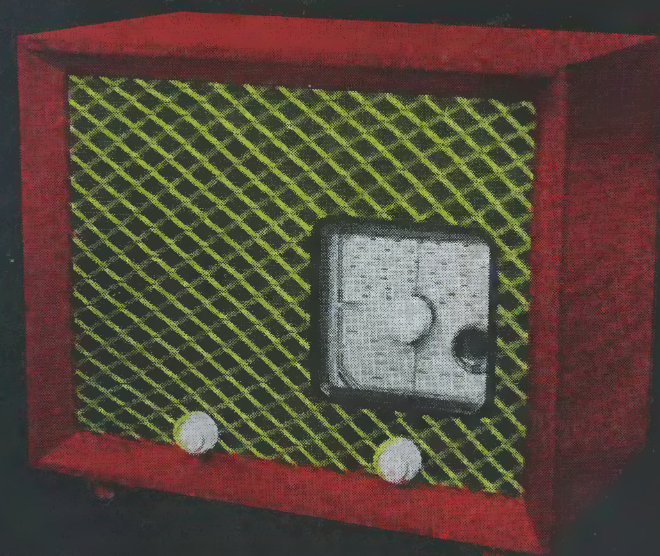
VOLUME 13
NUMBER 3
OCTOBER
1959

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS



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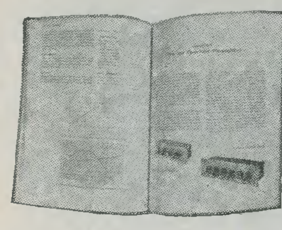

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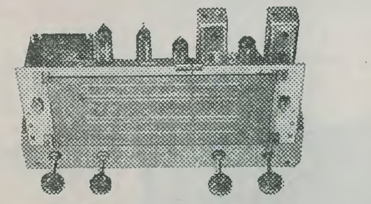

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16/450V	3/6	8+8/500V	5/–	6,000/6V	5/–
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32/450V	5/6	8+16/500V	5/6	50+50/350V	7/–
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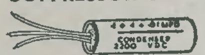

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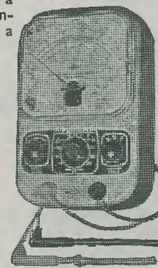
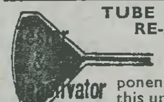
PULLIN SERIES 100 TEST SET



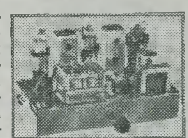
Undoubtedly a most useful instrument by a firm long famous for fine instruments, entirely re-designed, it has a square movement with diacon plastic cover this makes for a brighter, more readable scale, extra scale length and wider angle of vision. With the test set is included a pair of combined test prods and crocodile clips also a stand for inclining the meter at the best reading positions. Ranges A.C. Volts: 0–10, 0–25, 0–100, 0–250, 0–500, 0–1,000, ditto D.C. A.C. Current 0–100mA. D.C. Current 0–2.5, 0–10, 0–100, 0–500mA. Resistance: 0–1M and 0–10K. All at 10,000 ohms per volt—Price **£12.7.6** or **24/–** deposit and 26 Fortnightly payments of **10/–**, note h.p. price includes 12 months insurance.

TUBE TESTER AND RE-ACTIVATION



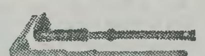
We can supply all the main components for making this unit which will not only test Cathode Ray Tubes but will also re-activate them. Supplied complete with full instructions. Price **£3**, plus 2/6 post and ins.

BEGINNER'S SUPERHET



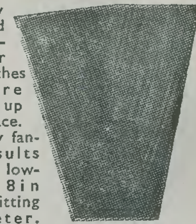
All the components including metal chassis, valves, metal rectifier, coils, tuning condenser, etc. etc., required to build the "Beginner's Superhet" are available as a parcel. Price **£3** plus 3/– post and insurance.

AVO PRODCLIPS



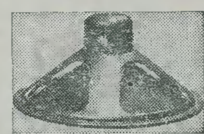
The advantage of these test prods is that by pressing the trigger at the side they become crocodile clips and can be left in circuit. This is a great time saver when servicing. Price **15/–** pair.

HI-FI SNIP Infinite Wall Baffle



Nicely veneered and polished. Corner fitting (attaches to picture rail). Takes up no floor space. Gives really fantastic results with only low-priced 8in speaker. Fitting for tweeter. Only **45/–** each. Carriage and insurance 3/6.

SPEAKER BARGAIN



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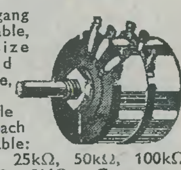

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Electronics (Croydon) Ltd.
266 London Road
Croydon
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with an authentic

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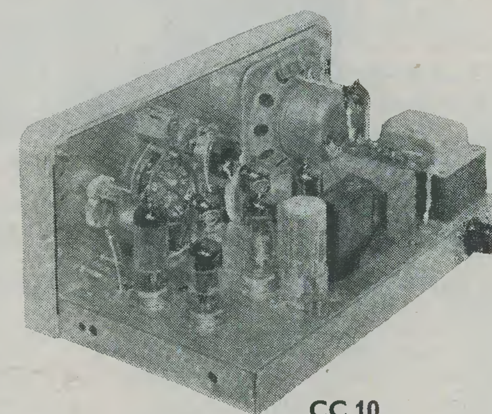

CC.10

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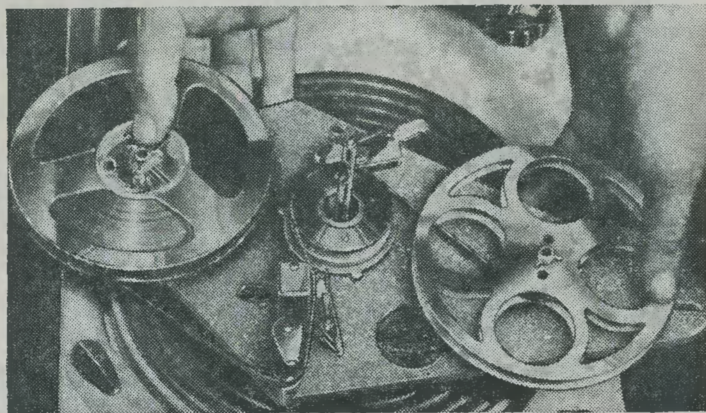

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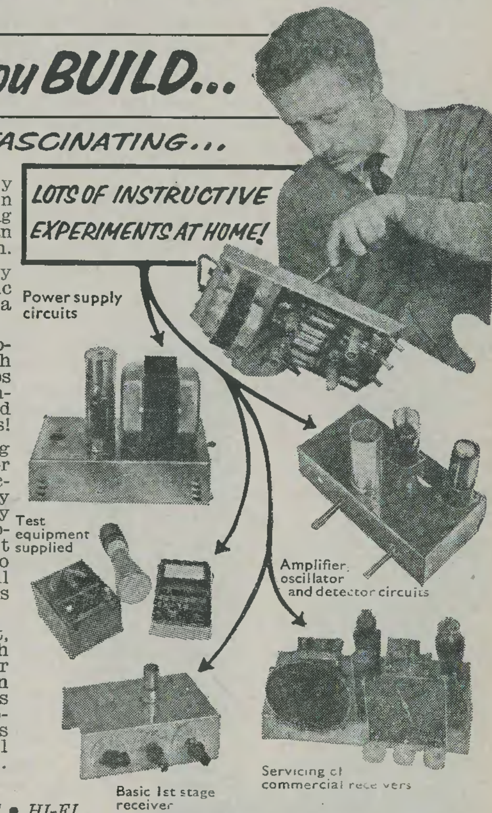

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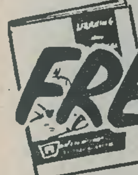

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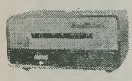

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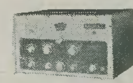
FM TUNER. This model is available as two units which, for your convenience, are sold separately. They comprise a Tuner Unit, Model FMT-4U (£3.2.0 including Purchase Tax) and an Amplifier Unit complete with attractively styled cabinet, power supply and valves, Model FMA-4U (£10.10.6) making a total cost for the equipment of **£13.12.6.**



DX-100U

S-3U

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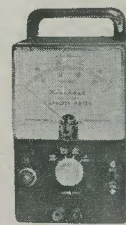
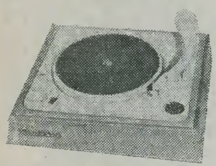


CM-1U



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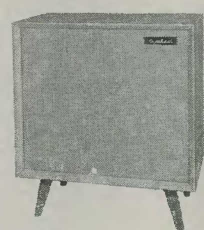
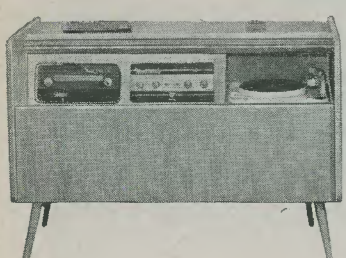


THE "COTSWOLD"



THE "GLOUCESTER"

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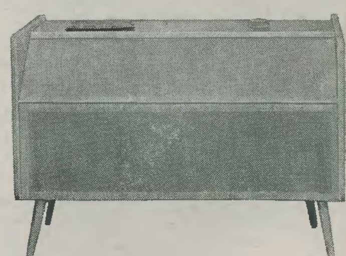

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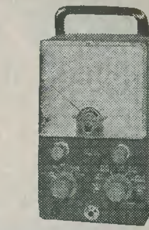
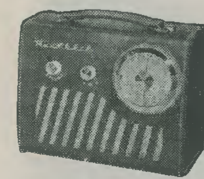


VALVE VOLTMETER
Model V-7A

EXAMPLES

CAPACITANCE/RESISTANCE BRIDGE C-3U. Measures capacity, 10pF to 1,000µF; Resistance, 100Ω to 5MΩ; Pwr. F'ctr. **£7.19.6** *(Not illustrated)*



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Model UXR-1

AUDIO GENERATOR: AG-9U. 10 volts, 10 c/s to 100 kc/s pure sine-wave. Switch-selected frequencies/attenuation. **£19.3.0**

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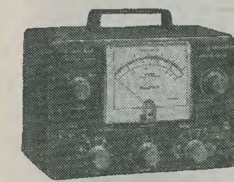
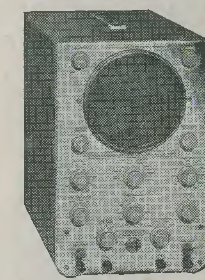


AUDIO GENERATOR
Model AG-9U



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HI-FI STEREO BOOSTER: USP-1. Input of 2 to 20mV gives output adjustable from 20mV to 2V. Negligible distn. **£5.19.6**

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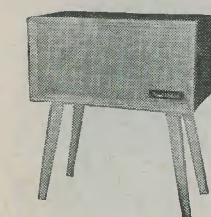

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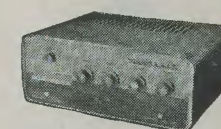

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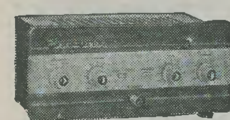

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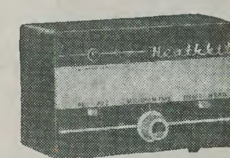

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Incorporating THE RADIO AMATEUR

Vol. 13 No. 3 OCTOBER 1959 ANNUAL SUBSCRIPTION 25/– (*including postage*)

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

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

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

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

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

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

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TEST EQUIPMENT

No. 107
A Simple Insulation Tester

suggested circuits

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

An instrument capable of checking insulation resistance is always of value in the amateur workshop. In this month's contribution the writer gives details of an insulation tester which functions on very simple principles, and which requires nothing elaborate in the way of calibration after construction has been completed. The tester has two range settings, one giving an indication of "better than 5MΩ" and the other an indication of "better than 20MΩ". These two range settings should be quite adequate for normal servicing and constructional work. However, should it be desired to make the instrument capable of measuring resistance between 5 and 20MΩ more accurately, this may be achieved by the inclusion of a more elaborate switching circuit. The accuracy of the device, as described here, is, at worst, of the order of ±10%. Higher degrees of accuracy could be achieved, but this would incur a complication in design and increase in cost which would be disproportionate to the advantage obtained.

The insulation tester should prove to be especially useful for checking insulation resistance in condensers, and it overcomes the misleading charge and discharge readings given by instruments having hand-driven generators.

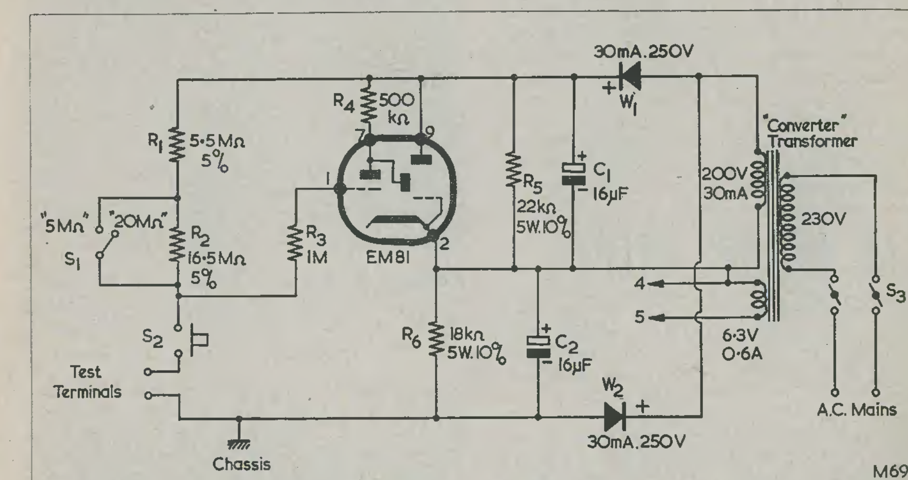
Insulation measurements are taken at a pressure of 200 volts approximately.

Operation

The circuit of the insulation tester accompanies this article. As may be seen, the power supply is obtained with the aid of a "converter" mains transformer having a half-wave 200 volts h.t. secondary. A "converter" transformer is ideal for an instrument of this type because of its small size and relatively low cost. The rectifiers W_1 and W_2 provide two d.c. potentials, one approximately 200 volts positive and the other 200 volts negative of the lower end of the mains transformer secondary winding. These two potentials are smoothed by reservoir condensers C_1 and C_2, whilst resistors R_5 and R_6 draw a continuous current around 10mA for purposes of stabilisation.

The rectified voltages from W_1 and W_2 feed the effective bridge given by the EM81 Magic Eye, R_1 (plus R_2 when S_1 is in the "20MΩ" position), and the resistance impressed across the test terminals. The cathode of the EM81 can be considered as connecting to a voltage lying midway between the upper end of R_1 and the lower test terminal. When the voltage on the grid of the EM81 is zero with respect to its cathode the shadow provided by this valve is open. When the EM81 grid voltage is 10 volts negative of its cathode the shadow is almost completely closed. With S_1 in the "5MΩ" position the value of R_1 is so chosen that a resistance of 5MΩ connected across the test terminals causes the grid voltage of the EM81 to be 10 volts negative of its cathode. Thus, values of 5MΩ and less connected across the test terminals cause the Magic Eye shadow to close. Values slightly higher than 5MΩ—up to 5.5MΩ—cause partial closing of the shadow, whilst higher values still allow it to remain open. With S_1 in the "20MΩ" position a similar state of affairs takes place. In this case the shadow closes for a test resistance of 20MΩ or less, is partially closed for test resistances up to 22MΩ, and remains open for higher values.

To employ the insulation tester in practice, it is first of all switched on and allowed to warm up, S_1 being set to the desired range. The circuit, or component, whose insulation it is desired to check is then connected across the test terminals, and push-button S_2 depressed. The resistance appearing across the test terminals may then be evaluated by observing the shadow of the Magic Eye. If a condenser, or a circuit possessing appreciable capacity, is connected across the test terminals it will be necessary to allow this to charge up to the test voltage before the insulation resistance may be finally evaluated. In this instance the immediate effect given by pressing S_2 will be an initial closing of the Magic Eye shadow, this opening out (if insulation resistance is satisfactory) after the condenser has become charged up.



Circuit Details

Whilst the use of a Magic Eye gives the circuit the advantage of simplicity, it also causes a slight complication in design. This is because the Magic Eye cannot function here as a true null indicator. Instead, we have the situation where indications are given over the grid voltage range zero to 10 volts negative of cathode.* As a result, it was considered desirable to arrange the bridge values such that when, with S_1 set to the "5MΩ" position, a resistance of 5MΩ was presented to the test terminals, a potential of 10 volts negative of cathode would appear on the grid of the EM81. Assuming that the rectified voltages across C_1 and C_2 are 200 (giving a total voltage across the two condensers in series of 400) the value of R_1 should then be such that 210 volts is dropped across this resistor and 190 volts across the 5MΩ test resistor. R_1, therefore, must have a value equal to $\frac{210}{190}$ times 5MΩ (i.e. 5.5MΩ approximately). When S_1 is set to the "20MΩ" position it is similarly necessary for R_1 and R_2 in series to have a combined value equal to $\frac{210}{190}$ times 20MΩ. The value of 22MΩ given by R_1 and R_2 in series meets this requirement with reasonable accuracy.

It will be noted that, when S_2 is not depressed, or when the test resistance has a value higher than that which would cause closure of the Magic Eye shadow, the grid of the EM81 draws grid current via R_1 and R_3, or R_1, R_2 and R_3. Due to the values specified for these resistors this grid current cannot rise to a value higher than some 31μA (when S_1 is in the "5MΩ" position), and this

* The grid voltage quoted by the manufacturers for 5 degrees shadow angle is 10.5 volts negative of cathode for an h.t. voltage of 250. The figure of 10 volts negative of cathode assumed in this circuit, wherein the h.t. voltage is 200, should in consequence be sufficiently accurate for our present requirements.

should not give rise to any trouble.

Another point is that the maker's recommendation of 3MΩ maximum d.c. resistance between grid and cathode of the EM81 is exceeded in the circuit. Because of this it is desirable to check operation of the unit occasionally with known resistors having values of 5 and 20MΩ respectively, in order to ensure that indication accuracy has not wandered.

The purpose of the 1MΩ resistor R_3 is merely that of limiting grid current in the event of accidental connection of the test terminals to a circuit which has a voltage impressed on it, or to a charged condenser.

The function of the two resistors R_5 and R_6 is that of providing stabilisation of the rectified voltages provided by W_1 and W_2. Assuming rectified voltages of 200, resistor R_5 draws a current of 9.1mA, whilst R_6 draws a current of 11.1mA. The Magic Eye draws a current of some 2mA at 200 volts, with the result that the current loading on both rectifiers is approximately equal. R_5 and R_6 have values which lie in the 10% preferred range.

The values of R_1 and R_2 will not be readily available and it will very probably be necessary to employ two or more single resistors in series to obtain the resistance figures specified in the diagram. If desired, it is possible to have more than the two range positions given by S_1, these being obtained by the simple process of making S_1 a multi-way switch which inserts, into the top half of the bridge, resistors having a $\frac{210}{190}$ ratio to the resistance range selected.

Components

Little difficulty should be experienced in obtaining the components required for the instrument, as these are standard types. The two rectifiers W_1 and W_2 can, very conveniently, be small contact-cooled units. It should be borne in mind that, if W_1 is bolted to the chassis, its insulation must be sufficiently good to withstand some 400 volts between its elements and its case. This is by no means an excessive requirement for a rectifier of reliable manufacture.

It should also be noted that whilst the negative terminal of C_2 is at chassis potential, that of C_1 is not. If the negative terminal of C_1 is common to its can the latter must be insulated from chassis.

Finally, it must be pointed out that care has to be taken to ensure that adequate insulation exists between chassis and the components connecting to the grid of the EM81. Poor insulation at this part of the circuit will cause the accuracy and reliability of the instrument to be degraded. Because of this requirement it would be advisable to mount S_1 and S_2 on a sheet of high-grade insulating material, rather than directly to a metal panel. Also, tag-strips are best avoided, whereupon R_3, R_2 and the lower end of R_1 should be connected direct to, and be supported by, the appropriate switch and valveholder tags. Adequate insulation must similarly, of course, be provided for the upper test terminal. Especial care needs to be taken with the EM81 valveholder as the tag corresponding to the grid pin will be very close to the cathode and heater tags. It would be advantageous here to use a high-quality moulded valveholder.

CAN ANYONE HELP?

BC1206A Receiver.—J. Aston, 28 The Glade, The Leas, Baldock, Herts, requires the circuit diagram and i.f. of this unit, also aerial connection details. Any help gratefully acknowledged and costs met.

* * *

Ex-R.A.F. Indicator Unit, type 302.—M. G. Boff, The Blue Bell Hotel, 170 Barlow Road, Levenshulme, Manchester 19, would like any data or information on this unit and is willing to pay any costs incurred.

* * *

Eddystone Short Wave Manual No. 6.—P. Woolland, 10 Brookside, Glapthorn, Nr. Peterborough, Northants, wishes to buy or borrow a copy of this manual. If borrowed, will meet expenses.

* * *

Wave-Meter type W1117.—B. G. Ellis, 27 Oldfield Street, Leeds 12, would like any information on this meter. Beg, borrow or buy circuit diagram—expenses refunded.

* * *

Philips Amplifier type 2856R.—H. Rimmer, 52 Racks Parade, Blackpool, Lancs, wishes to buy or borrow circuit and any other data. All costs willingly met.

* * *

Trans-Receiver type CR1-43044.—W. A. Yeomans, 13 Council Street, Walton, Peterborough, Northants, has acquired this unit of the TBY-7 radio equipment made by Colonial Radio Corporation of New York, and wishes to buy or borrow any information data and circuit. All expenses refunded.

* * *

Wireless Set No. 31, ZA31385.—C. Galloway, 177 Broom Lane, Levenshulme, Manchester 19, requires any information on this unit. Any expenses fully refunded.

* * *

Indicator Unit type 184A, ref. No. 100B/6181A.—A. Thompson, 199 Victoria Avenue, Hull, wishes to obtain circuit diagram and/or data of above unit. Can anyone help, please?

This month Smithy the Serviceman gives his able assistant, Dick, some information on the basic facts of efficient working

"AND THERE'S ANOTHER THING," SAID Smithy truculently, "why is the pianist in a skiffle band not allowed to sit down?"

Dick suppressed a grin. He and the Serviceman were engaged in their perennial argument about modern "pop" music, Dick hotly defending the latest offerings of the record companies and Smithy just as hotly attacking them.

"I think it's nothing short of cruel," continued Smithy. "The piano keyboard is just the right height to sit down at, but the strain on the lumbar muscles for anyone who has to play it standing up must be something shocking."

"A keen musician wouldn't notice it," interjected Dick, trying to keep his face straight. "He'd just take it in his stride."

"Nonsense!" retorted Smithy. "I think it's an open-and-shut case for the Factory Inspector to look into. If not," he added, darkly, "for the Musicians' Union. What are *you* sniggering about?"

"I'm sorry, Smithy," laughed Dick, "but I just couldn't help it. After all, you can't slate the music just because the pianist has to stand up."

"Of course I can," exploded the Serviceman. "The whole thing's so damned *silly*. Can you imagine Moiseiwitsch standing up when *he* plays?"

"Ah, that's different. Isn't he that new chap who only plays trad?"

"Trad?"

"New Orleans."

Smithy looked baffled.

"Well," he said, after a moment, "let's try another tack. Don't you think the music would sound better if the players were able to do their jobs more efficiently?"

"No, not really."

There was a further moment's silence as Smithy considered Dick's remark.

"Hmm," he said, eventually, "perhaps you're right."

Time and Motion Study

However, Smithy didn't seem prepared to let this particular aspect of the argument peter out.

"No, but joking apart," he resumed, "I don't want to dismiss too lightly the idea of efficient operation, as resulting for instance from such things as Time and Motion Study. Applying Time and Motion Study to a skiffle band could produce interesting results and might even do something to the aesthetic —and I choke over the word—quality of the sound it makes."

"It's me that's a little lost now," complained Dick. "To start with, I'm not certain just what Time and Motion really stands for."

"Ah," said Smithy, gratified at being able to expound on one of his favourite subjects. "Well, really, it's just one of those common-sense things which has become specialised and which has grown into a little science of its own. Time and Motion Study started off when people commenced attempting to reduce the time taken to do assembly jobs in mass-production factories, and also to reduce the fatigue experienced by the operators who did them."

"Why the latter?"

"There are several reasons," said Smithy. "From the hard-headed business point of view you could say that the less fatigue an operator suffers, the less mistakes he, or she, makes on the operation. But it isn't only that, of course. It is obviously sensible to keep fatigue down to the minimum from the point of view of the morale of the operator."

"It sounds a bit cold-blooded to me," remarked Dick. "As though you were thinking of the operator as a machine."

A light was starting to dawn in Dick's eyes.

"I begin to see what you're getting at," he exclaimed. "When I saw the first layout I thought it seemed sensible enough. But your second layout is so obviously better that it sticks out a mile! And yet the change seems to be of a very simple order."

"It *is* simple," agreed Smithy. "As are so many other things after they've been explained to you. Now, what I've shown you

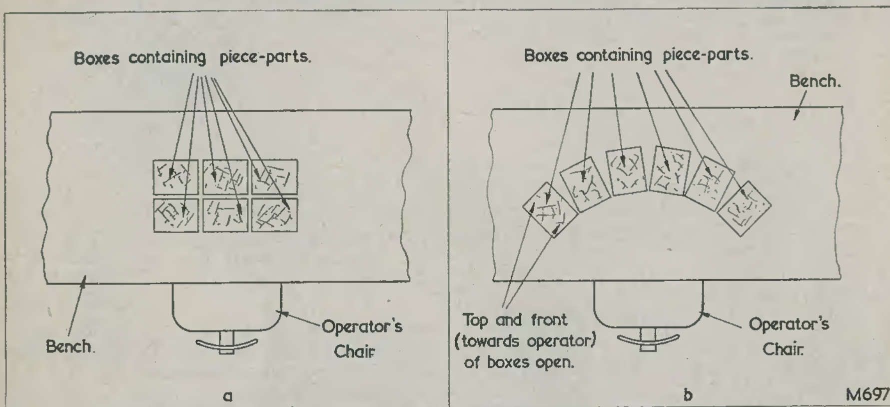


Fig. 1 (a) An inefficient work layout. The operator assembles the six piece-parts in the boxes. (b) A much more efficient layout, by means of which the operator may pick up the piece-parts more quickly and easily

"To be quite honest, it always sounds a little that way to me as well," confessed Smithy. "But I must repeat that Time and Motion ideas all come back to common-sense when you analyse them. For instance, here's the sort of operation layout you used to get in a factory in the old days (Fig. 1 (*a*)). The girl sitting at the bench in my sketch is supposed to assemble six different things together before she passes the completed article on to the next girl. All the six piece-parts are laid out in six little boxes in front of her."

"Seems sensible enough to me."

"Perhaps so," said the Serviceman, "but it can be improved. After the Time and Motion boys have had a go at a layout of this nature it would probably look something like this (Fig. 1 (*b*)). In this case all the operator's piece-parts now appear in boxes arranged in an arc of a circle. The boxes all open out towards her and she can see at a glance what they contain. Also, they're all the same distance away from her so she only has to think in terms of *direction* when she reaches out for a particular part. With the old idea she not only had to think of *direction* but of *distance* as well."

is an obvious example of the sort of thing that Time and Motion techniques can achieve. I'm quite certain that much the same sort of idea can be applied to servicing."

"But our sort of work is different from factory work," protested Dick. "In a factory people do the same thing over and over again, whereas we are changing about all the time."

"That's not entirely true," said Smithy. "There are many instances when you carry on with a routine and unvarying job for quite long periods of time. As, for example, when you have an awkward snag, and you want to contemplatively prod the chassis around a bit. Let's assume that the snag you're chasing is of the type where you need a test-meter only. In this case I think that there's nothing better than laying things out like this. (Fig. 2 (*a*).) Give yourself plenty of free surface area—that's *most* important. Then put your testmeter up really *close* to the chassis, so that you can well-nigh see its needle out of the corner of your eye whilst you're prodding. Quite often it is difficult to hold a meter prod firmly in position on a particular test point, and so you don't want to have your eye travel very far to see the

reading given by the test connection. Indeed, with my layout, all you need do is to roll your eye slightly to the right and the deed is done. There's no necessity even to shift your head. Certainly not your body."

"I suppose you've got something there," said Dick a little grudgingly, "but if you feel that way, why do we have shelves fixed above all the benches in the Workshop? Aren't testmeters and things meant to go on these?"

"In the main, no," said Smithy, "and, quite definitely, not test equipment in use and of the type which has to be frequently consulted. Look, here's what happens if you put a test-meter on a shelf. (Fig. 3 (*a*).) As you can see straightaway, whenever you want to look at the meter scale you have to at least move your head, and very probably alter your body position as well. Which means that you take quite a lot of your attention away from the chassis. The result is that, in many cases, your test prod will fall off the point to which it is supposed to connect, and may even touch a point you *don't* want to connect to. Also, having the meter on the shelf means that whilst you're looking inside the chassis you may miss those occasions when its needle swings hard over. If the meter's alongside the chassis you can usually see this effect quickly enough to remove the test prod before any serious damage gets done. Another point is that, with the shelf, you have to reach up every time you want to change the meter range. When the meter's on the bench its range switch is right under your hand. Yet again, there's a strong possibility that the meter on the shelf will be further away from you than it would be on the bench so that, firstly, you can't see its scale so clearly and, secondly, you have to re-focus your eyes each time you look up at it."

"Couldn't you get over this last difficulty by making the shelf poke out a bit more?"

"Well, you *could*," said Smithy, somewhat dubiously, "but you'd then find that either you reduce your effective bench working area or you reduce your shelf accessibility. If a shelf which pokes out a long way is too low it makes it difficult to work below it, especially on large and cumbersome chassis. (Fig. 3 (*b*).) If you raise it, to overcome this snag, then it means you have to reach too high."

"You must admit," grinned Dick, "that you are exaggerating these effects in your sketches."

"Perhaps so," conceded Smithy. "But a little exaggeration does help sometimes to bring home an argument. Before finishing on this subject, however, I will agree that if, due to lack of floor space, you have to use a narrow *bench*, you can more satisfactorily fix up a shelf whose distance to the eye is similar to that of the surface of the bench. (Fig. 3 (*c*).) But, even so, I still wouldn't put any testmeter in continual use on such a shelf."

Finer Points

"Okey-dokey," said Dick. "I'm prepared to be convinced. The testmeter stays on the bench close to the chassis being serviced."

"Right," said Smithy briskly. "Now the next thing to consider is the other information you need for fault diagnosis. If the chassis is that of a sound radio you want to hear what sort of noise comes out of its speaker. To do this you either hitch the output circuit to the bench speaker, or use the set's own speaker. You know, it's a good thing to mount whichever speaker you're using fairly close to, and 'aimed' at, your ears; because you can then hear hiss and tops much more readily. You can arrange for this quite easily so far as the bench speaker is concerned. If the job being serviced is a t.v. chassis, you will very frequently want to keep an eye on the screen, whereupon we call in one of our mirrors.[1] Like so. (Fig. 2 (*b*).)

"Well, our layout seems very sensible up to now," remarked Dick. "Once you've got everything set up you just plant yourself on your stool and stay there till you find the snag."

"Which is the entire basis of the idea," exclaimed Smithy. "Now, you'll obviously want a few tools and things. Most of these you can keep alongside you on the bench—preferably in a shallow box wherein you

[1] These were described in last month's "In Your Workshop."

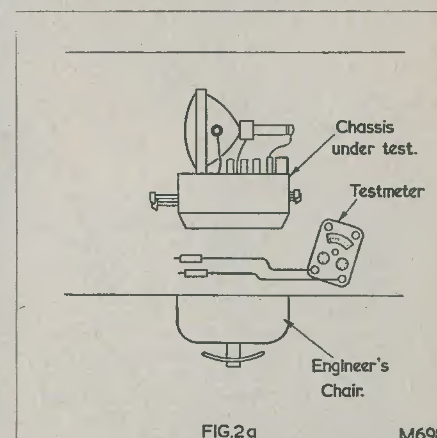


Fig. 2. Successive steps in making up an efficient trouble-shooting work layout. (a) The testmeter should be placed on the bench close to the chassis under test

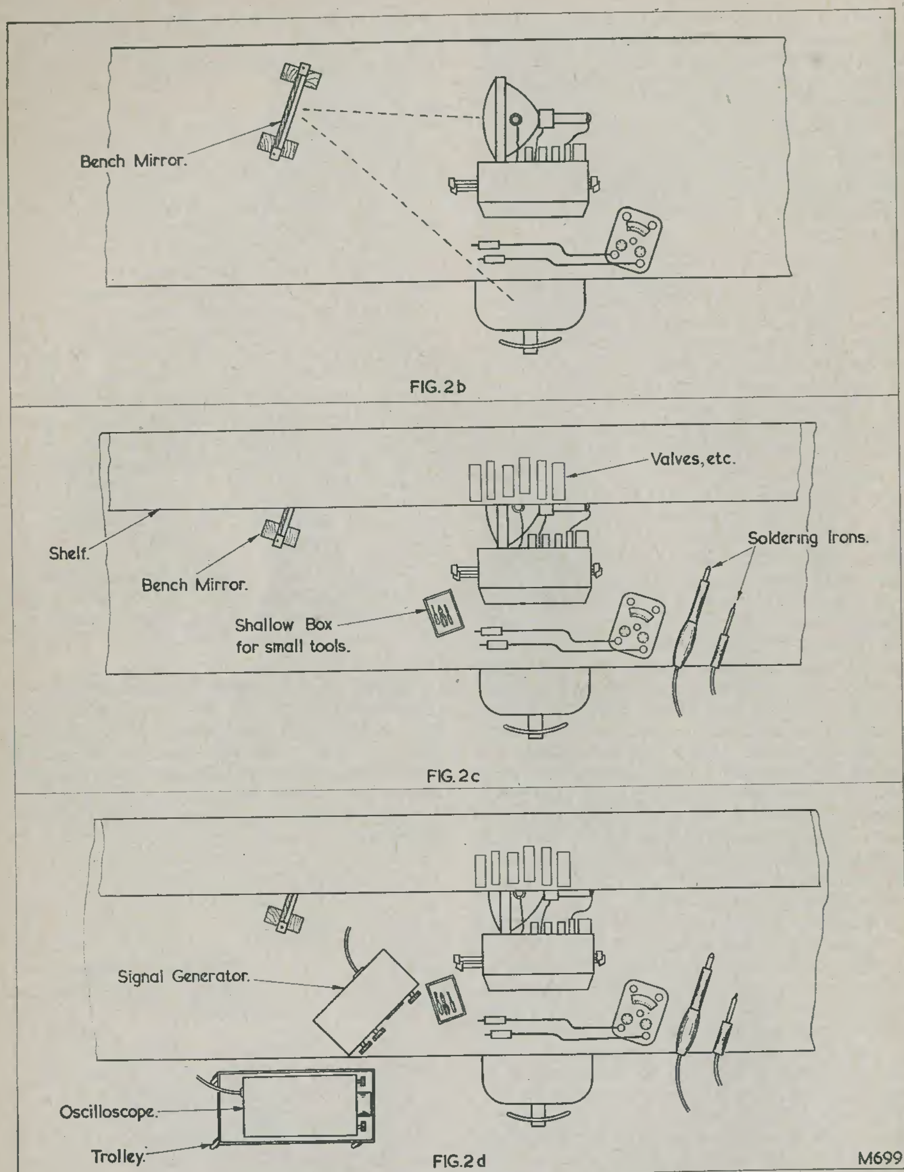


Fig. 2 (b) A conveniently placed mirror enables the engineer to see the receiver screen without moving from his chair. (c) A shelf is useful for holding the more frequently employed spare parts and valves. Also, soldering irons and small tools should be kept within easy range. (d) Large, bulky test instruments may be fairly readily inserted into the layout. A trolley for the oscilloscope is a useful adjunct

can see them and pick them up readily."

"And how long will they stay in the box?" said Dick, somewhat sarcastically.

"If you're like me, not very long," admitted the Serviceman. "They will soon spread themselves over the surface of the

bench. Nevertheless, the mere existence of a box seems to inspire a homing instinct in the tools and they should be in it *most* of the time! Don't forget that you won't need very many tools for actual trouble-shooting. Hammers and jemmies are O.K. for initially getting the works out of the box, but once the chassis is on the bench it's mostly light engineering."

"What about solder and soldering iron?"

"What I usually do with solder," said Smithy, "is to have about a yard or two of it in the shallow box along with the tools. You can easily make it up into a convenient coil by wrapping it round your hand.

"So far as soldering irons are concerned it's not a bad idea to have *two*, one big and one small, and both switched on and ready to go. The small one can be one of those modern tiny irons which are so excellent for the awkward little jobs you get these days. The big one is retained for tackling the beefier joints."

"I see," said Dick musingly "All this sounds excellent in theory, but I can't see it turning out quite so well in practice. For instance, I always have to keep leaving the bench for different things whilst I'm servicing."

"True enough," said Smithy, "but you must remember that I'm talking about trouble-shooting only. I appreciate that, after you've *found* your fault, you may have to go to the spares cupboard to find a replacement for the faulty component. In the meantime, however, you will have saved time and energy in the process of *tracing* that component. And, of course, there's nothing to stop you keeping a stock of the more commonly encountered resistors and condensers fairly close at hand, together with a representative selection of valves. These can go on your shelf, if you like. Dear me, my sketch is getting quite detailed now." (Fig. 2 (c)).

"Detailed it may be," said Dick, "but it still looks too good to be true. There's not even *half* enough junk around for my liking!"

"Fair comment," grinned Smithy. "I would be the first to agree that a really tidy bench often indicates that there's not much work going on! You must assume that the working space in my sketch has been cleared of odds and ends."

"What about ancillary equipment? Such as the signal genny?"

"Ah," said Smithy. "Now things begin to get more difficult. I'm a great believer in really small signal gennies—provided they're efficient enough—because you can put these on the bench with their scales and knobs pointing upwards, just like the testmeter. Nevertheless, even if the signal genny is large

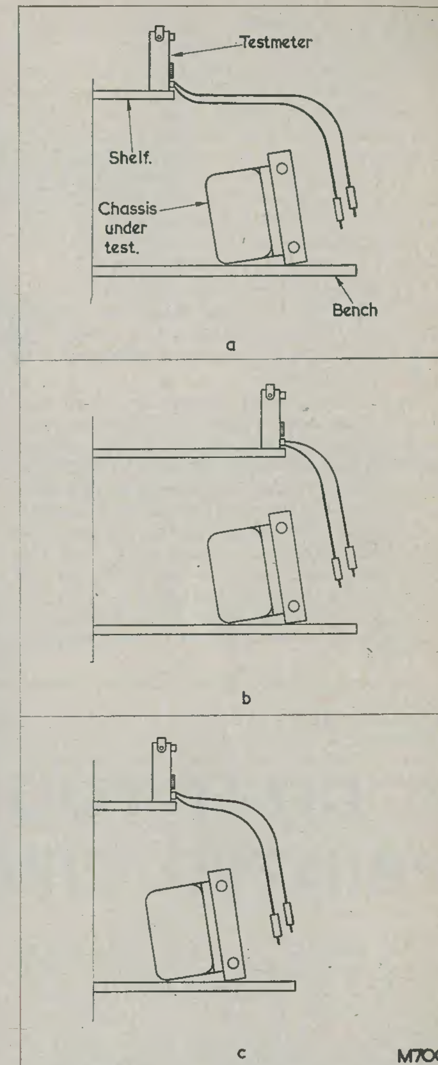


Fig. 3 (a) It is normally inconvenient to have test equipment in constant use mounted on a shelf. (b) Extending the shelf has the effect of limiting the working area of the bench. (c) It is sometimes possible to reach a compromise solution on shelf location when a narrow bench is employed. Even so it is not recommended that such a shelf be employed for test equipment in constant use

and cumbersome it's still worth while trying to keep it at bench level. The signal genny can frequently go on the other side of the chassis to the testmeter, with the result that the layout is still quite reasonable.

"Other bits of equipment raise problems, too. 'Scopes are especially liable to be heavy and cumbersome, whereupon it isn't a bad idea to mount them on trolleys which can be wheeled up to the bench when required.[2] If I add a signal genny and a 'scope to my sketch I get a layout like this. (Fig. 2 (*d*).) Even now, with all the heavy gear around, the chap who's doing the work still has things within comfortable reaching distance."

"I'll agree that everything is close to hand," said Dick, "but now that things are getting more complicated another point comes up. Aren't you liable to waste time getting all this stuff into position?"

"Not half as much as you do when you have to keep moving around and leaving your stool to adjust knobs and get things," replied the Serviceman. "Incidentally, you may have noticed that I've used the same basic principle for the trouble-shooting layout as I showed you, right at the beginning, for the operator assembling those six piece-points. All the tools, scales and twiddles which the service engineer has to use or attend to are laid out around him in an arc of a circle. All more or less at the same distance from him, and all more or less at the same level."

"Why, so you have!" exclaimed Dick. "I hadn't realised that."

Preparing For Work

"Right," said Smithy, rubbing his hands together briskly, "and now let's get back to the grindstone."

"O.K., Smithy. But let me first take advantage of your advice and clear a really man-sized working area on my bench."

Whereupon Dick, with a careless sweep of his arm, pushed all the detritus from the front of his bench up against the back. This action resulted in considerable rattle and clatter, together with that unpleasant scraping noise which is given when valve rubs against valve. Some of the components escaped from the unstable pile which Dick had created, and rolled, or fell, forward. Dick merely flicked these back again, whereupon they remained indeterminately in position. Satisfied, Dick turned round to the Serviceman.

But Smithy, who had been watching his assistant's actions with horror, had turned away.

"Just dig," he remarked hopelessly to the Workshop. "just dig my crazy boy."

2 Specially designed trolleys for oscilloscopes are available from the manufacturers of some of the larger instruments.

TRADE REVIEW

A DO-IT-YOURSELF PRINTED CIRCUIT KIT

The staff of *The Radio Constructor* recently received for test from Proops Bros. Ltd. a kit for the production of printed circuit boards by the home constructor himself.

The kit comprises three copper laminated circuit boards, each 6in x 3½in, a rubber sucker for handling the boards, cleaning powder, etch-resisting ink, a paint brush, etching chemical, ink solvent and a very comprehensive instruction booklet. The kit is packed in a Perspex box which is used to hold the chemical during etching.

The enthusiast will find that he can produce most professional results with a little care. The method of use described in the instruction booklet is very straightforward and clearly explained. Two examples of printed circuit design, a single transistor receiver and a four transistor hearing aid, are given in the booklet.

The method of use is as follows. The board is cut to the required size with a fine saw and cleaned with the abrasive powder, applied on a damp cloth, until the copper coating is quite clean and free from grease. After rinsing and drying, the circuit is drawn or traced on to the copper with a soft pencil and filled in with the resist ink. When the ink has dried the board is immersed face downwards in the etching solution, holding it by means of the sucker. The etching process is complete in about twenty minutes, by which time all the unprotected copper will have been dissolved away. The board is then removed, rinsed thoroughly and the resist ink removed with the solvent and cleaning powder. The result is a most professional printed circuit to your own design at low cost.

The kit is obtainable from Proops Brothers Ltd. at a cost of 19s. 6d., postage and packing 1s. 6d.

UNDERSTANDING TELEVISION

PART 21

By W. G. MORLEY

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

In last month's contribution we discussed the circuit between the video amplifier anode and the cathode ray tube modulating electrode, and we concluded by pointing out the difficulties which exist if an attempt is made to couple the anode direct to the modulating electrode. Such a method of connection is liable to cause the potential difference between cathode and heater to rise under certain conditions to a value sufficiently high to introduce the risk of breakdown between these two electrodes.

A.C. Coupling

A simple method of coupling the video amplifier anode to the cathode ray tube modulating electrode which obviates the risk of excessive cathode-heater potential differences is illustrated in Fig. 116. It is assumed that the tube is cathode-modulated. In Fig. 116 the potential on the cathode ray tube cathode is maintained at a safe potential relative to the heater by means of the two fixed resistors R_2 and R_3 connected across the h.t. supply. At the same time the video signal is transferred from the video amplifier anode to the tube cathode via the coupling condenser. This condenser does not allow the passage of d.c., but it permits the transference of the alternating component of the signal to the tube cathode.

This last statement may be more readily understood if we examine a few instances of what takes place when a condenser provides the coupling link for a video signal. Let us assume, for instance, that the signal appearing at the anode of the video amplifier has the appearance of that shown in Fig. 117 (*a*). The waveform shown here is typical of several of the lines which would be given if a scene having a large amount of high illumination were being handled by the television system. Since the coupling condenser does not allow the passage of d.c. the signal will appear on the cathode of the tube as an alternating waveform having an *average voltage*, the latter being the sum of all the voltages occurring in a complete cycle. The cathode of the tube already has a voltage applied to it by R_2 and R_3, and the average voltage of the signal will tend to coincide with that given by these two resistors. The result is that the waveform may be applied to the cathode voltage/brightness curve of the tube in the manner shown in Fig. 117 (*b*).

Should the signal at the video amplifier anode have the appearance illustrated in Fig. 117 (*c*)—which is typical of several lines from a scene which is largely dark in character—the average voltage appears closer to blanking level. If this signal were, now, to be applied to the cathode ray tube under the same conditions as applied in Fig. 117 (*b*) we would get the effect shown in Fig. 117 (*d*). In both diagrams the average voltage of the signal tends to coincide with that at the junction of R_2 and R_3, but it is only the large amplitude signal of Fig. 117 (*b*) which is reproduced correctly by the tube. All parts of the low amplitude signal of Fig. 117 (*d*) are reproduced at a brightness markedly higher than that they truly represent.

It may be readily appreciated that the reverse effect to that we have just seen may also take place when the cathode ray tube grid-cathode potentials are adjusted so as to give correct reproduction of a dark scene. If condenser coupling were employed, a subsequent scene with high illumination would be reproduced incorrectly. An example of what would then occur is illustrated in Fig. 117 (*e*).

video amplifier and the cathode ray tube. The first of these is that it solves, very cheaply, the problem of feeding a video signal to the cathode ray tube without incurring high cathode-heater potential differences. Secondly, since the condenser coupling causes all scenes reproduced on the cathode ray tube screen to tend towards a constant brightness level, variations in final anode e.h.t. current become reduced in consequence. This helps to mask the effects given by shortcomings in e.h.t. voltage regulation.[2] Thirdly, it is sometimes stated that condenser coupling between the video amplifier and the cathode ray tube tends to minimise the visible effect of high-speed fading of the "aircraft flutter" variety.

Since condenser coupling only allows the passage of the alternating component of the video signal it is usually referred to as *a.c. coupling*. The direct method of coupling is

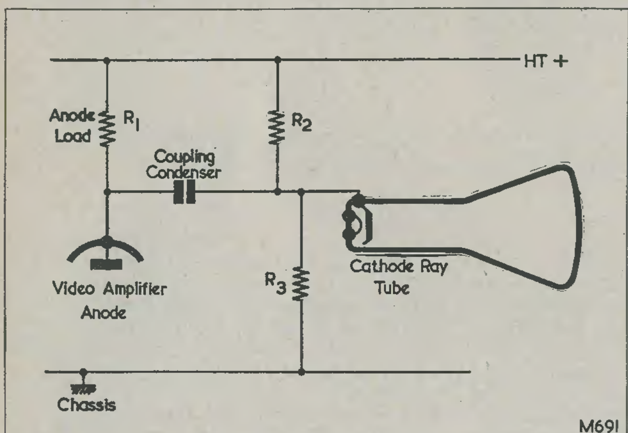


Fig. 116. *A frequently employed method of coupling the video amplifier anode to the modulating electrode of the cathode ray tube consists of employing a coupling condenser. This has the advantage of enabling any desired potential to be applied to the modulating electrode, and the disadvantage that the coupling does not allow the passage of the d.c. component of the video signal*

The various examples given in Fig. 117 show that with condenser coupling between the video amplifier anode and the cathode ray tube modulating electrode it is impossible to obtain true reproduction of scenes having varying levels of illumination. Despite this fact, condenser coupling in this part of the circuit is frequently employed in television receivers, it being assumed that the discrepancies introduced may be overcome by a compromise setting of the brightness control (which, of course, governs the grid-cathode biasing voltage). Usually the brightness control is set such that brightly illuminated scenes may be reproduced correctly, the darker scenes then appearing at heightened illumination.[1]

There are several main reasons for the popularity of condenser coupling between the

then described as *d.c. coupling*. In the present context we are considering the effects of a.c. coupling between the video amplifier and the cathode ray tube, but it should be pointed out that similar effects will occur if an a.c. coupling appears elsewhere in a video circuit.

Partial D.C. Coupling

A compromise between a.c. and d.c. coupling circuits which is occasionally employed is illustrated in Fig. 118. This diagram depicts what is referred to as *partial*

[1] Effects similar to those given by the condenser coupling occur also when certain types of a.g.c. system are used. These will be discussed in a later article.

[2] The voltage from a poorly regulated e.h.t. supply will drop excessively as current drain increases, with the result that the deflection given by the deflector coils increases. Thus, if the reproduced scene changed rapidly from dark to bright there would be an impression of the picture "opening out," (or, to use a common engineering term for this effect, "blooming"). Also, efficiency of spot focus, which is dependent upon a reasonably stable e.h.t. voltage, may suffer when this voltage varies.

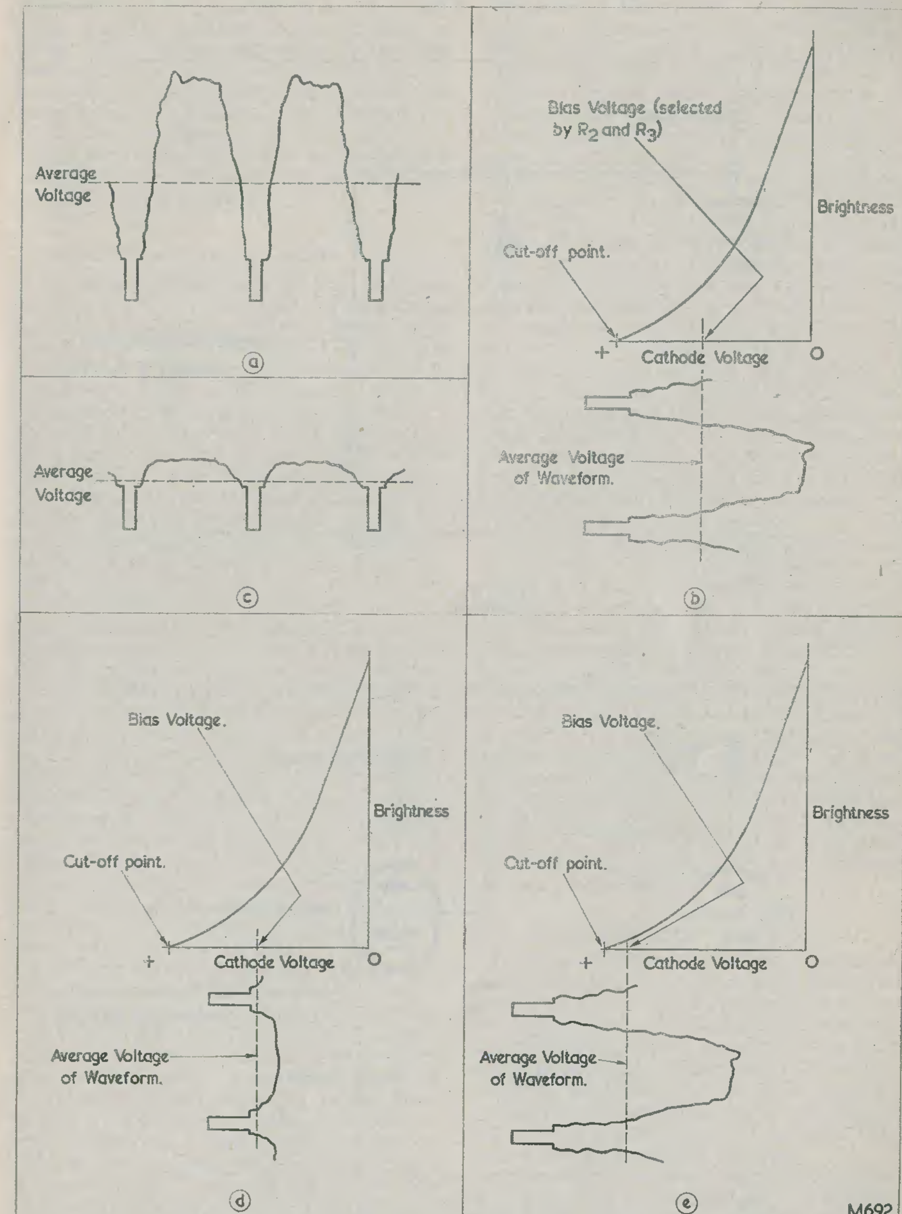
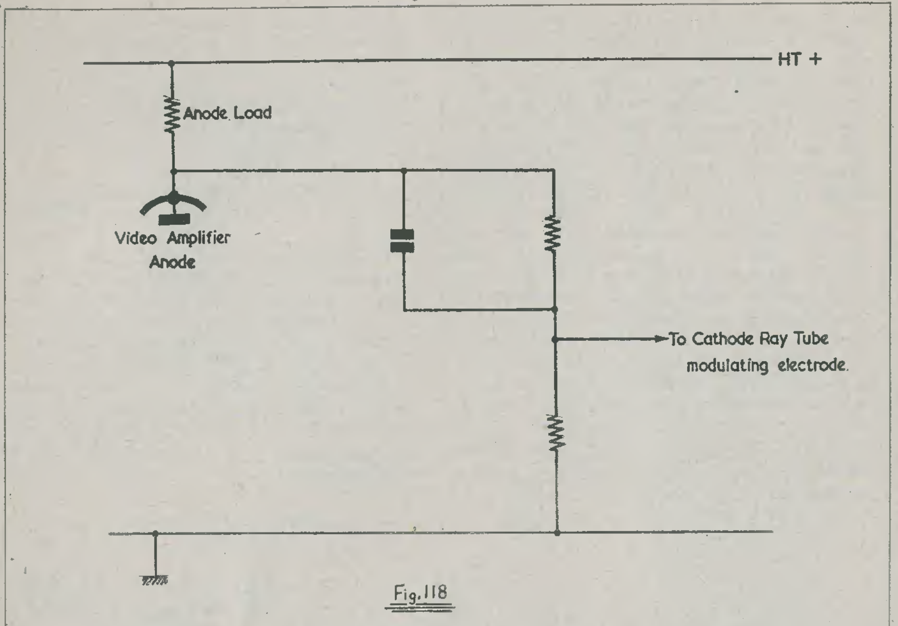


Fig. 117 (*a*) *The position taken up by the average voltage of a video signal having large amplitude picture information.* (*b*) *The signal of* (*a*) *passed via an a.c. coupling to the cathode ray tube.* (*c*) *A video signal with low amplitude picture information.* (*d*) *If the signal of* (c) *is passed to the cathode ray tube under the same conditions as was that of* (*a*), *we get the resultant effect shown here.* (*e*) *If the cathode ray tube bias were adjusted to accept, with an a.c. coupling, the signal of* (c), *the signal of* (*a*) *would be applied as illustrated here*

3A



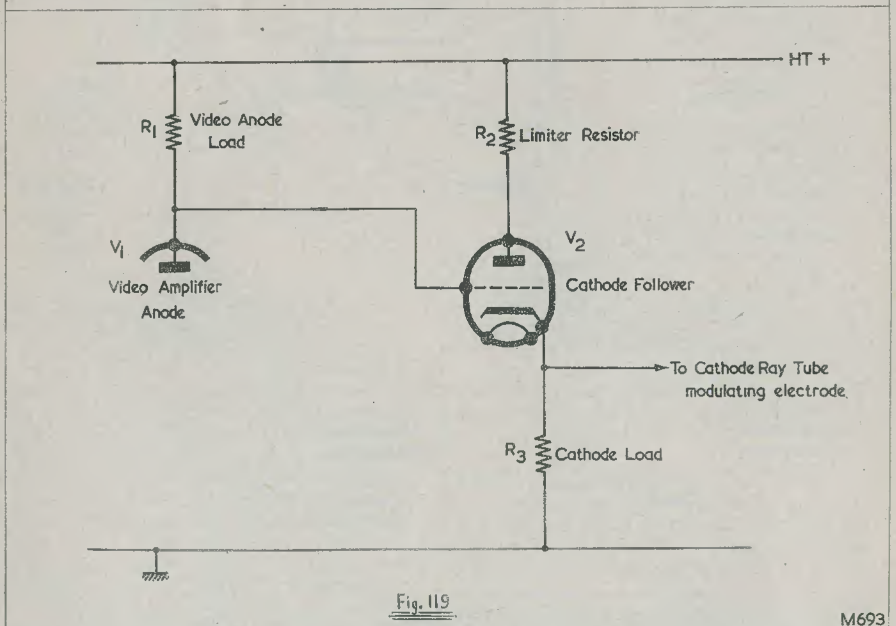


Fig. 118. A partial d.c. coupling between the video amplifier anode and the cathode ray tube. Fig. 119. Another method of coupling the video amplifier to the cathode ray tube. In this instance a cathode follower is employed

d.c. coupling. In Fig. 118 the anode of the video amplifier connects to two resistors in series, the cathode ray tube modulating electrode being fed from their junction. A condenser across the top resistor allows the passage of the higher video frequencies. With this arrangement it is possible to reduce the voltage applied to the modulating electrode whilst still retaining, partially, the effect of a direct coupling.

Cathode Follower Output Circuits

An elegant method of coupling the video output anode to the cathode ray tube consists of inserting a cathode follower stage between the two, as in Fig. 119. In this diagram V_1 is the video amplifier and V_2 is the cathode follower. The anode voltage of the cathode follower is fixed (the value of R_2 being of the order of 100 to 200Ω only) and the input grid voltage is obtained by direct connection to the video amplifier anode. The output of the cathode follower then appears across its cathode load. Whilst the cathode follower can only give a stage gain which is slightly less than unity, it has the considerable advantage of offering an extremely high input impedance, and of providing an output which may feed into low impedance circuits. At video frequencies the high impedance of V_2 shows itself mainly as a very low input capacity, a typical practical example being of the order of 1pF only. This capacity is much lower than that given when the video amplifier anode couples immediately to the cathode ray tube, with the result that the high frequency compensating components needed with the latter type of coupling circuit are not normally required. Thus, the video amplifier anode load may consist of a single, relatively high-value, resistor on its own. Assuming a maximum video frequency of 3Mc/s, a typical value for R_1 in Fig. 119 would be of the order of 15kΩ.

Under normal conditions the cathode of a cathode follower is always slightly positive of its grid. Thus, the cathode of V_2 in Fig. 119 will be slightly positive of the signal potential on the anode of V_1. The resultant effect will be that the coupling provided by the valve will be almost identical to that given by a direct connection. The cathode follower also provides a means whereby the heater-cathode potential difference in the cathode ray tube may be kept within safe limits. We have previously seen[3] that it is possible, immediately after switching on the receiver, for the anode to attain full h.t. potential if this becomes available before the video amplifier has warmed up. With the arrangement of Fig. 119, the voltage applied to the cathode ray tube remains at chassis potential until the cathode follower warms up. Also, whilst under normal working conditions without the cathode follower circuit it is possible for the video amplifier anode to approach full h.t. potential during cut-off periods (caused by such things as an excessive input signal), the cathode follower circuit reduces this tendency and also reduces the voltage passed on to the cathode ray tube. This is due to the fact that the d.c. anode resistance of the cathode follower increases when the potential between its anode and cathode is reduced to a low value. In the instance illustrated in Fig. 119, cut-off in V_1 will cause its anode to rise to a potential which will be limited by the flow of grid current in R_1, V_2 and R_3. The cathode of V_2 will then have a potential slightly lower than that on its grid, this being significantly lower than the full h.t. potential. Thus, even under conditions of cut-off in the video amplifier, the cathode follower prevents full h.t. potential being applied to the modulating electrode of the cathode ray tube.

When the video amplifier-cathode follower arrangement is employed in practical receivers it is very common practice to use a combined triode-pentode, the pentode being the video amplifier. Usual values for the cathode load of the cathode follower are of the order of 10 to 20kΩ, assuming a maximum video frequency of 3 Mc/s. Occasionally, the cathode load may be made a variable potentiometer, this then becoming the contrast control for the receiver. The slider of the potentiometer connects to the modulating electrode of the cathode ray tube, and special precautions have to be taken to ensure that stray capacities do not cause frequency response to vary for different settings of this control.

D.C. Restorer Circuits

It is possible, by means of what are known as *d.c. restorer*, or *d.c. reinsertion*, circuits to overcome the loss of d.c. component incurred by a video signal after it has passed through an a.c. coupling. Such circuits are not often encountered in the video stages of modern receivers, especially insofar as the coupling between video amplifier anode and cathode ray tube is concerned, but they have been used quite frequently in the past.

A typical d.c. restorer circuit is illustrated in Fig. 120 (*a*). In this diagram a video signal with positive-going sync pulses is passed, via a coupling condenser, to a load resistor and a diode. The diode conducts when its anode is positive of its cathode, with the result that the coupling condenser takes up a charge such that the positive tips of the sync pulses appear on the diode anode at a point slightly positive of cathode potential. See Fig.

[3] In last month's article.

120 (*b*). If the signal increases in amplitude the sync pulse tips on the diode anode still take up the same potential. The same effect occurs if signal amplitude decreases, because the coupling condenser then loses part of its charge via the load resistor and the internal resistance of the signal source; and, once again, the sync pulse tips appear at an anode voltage slightly positive of cathode potential.

Since the height of the sync pulses in a video signal is constant, regardless of picture information amplitude, it follows that by making their tips appear at a constant potential all the remaining parts of the signal take up their correct positions relative to that potential. As a result the signal now has the same appearance as it had before it was passed through the a.c. coupling, and it can be said that the diode has restored its d.c. component.

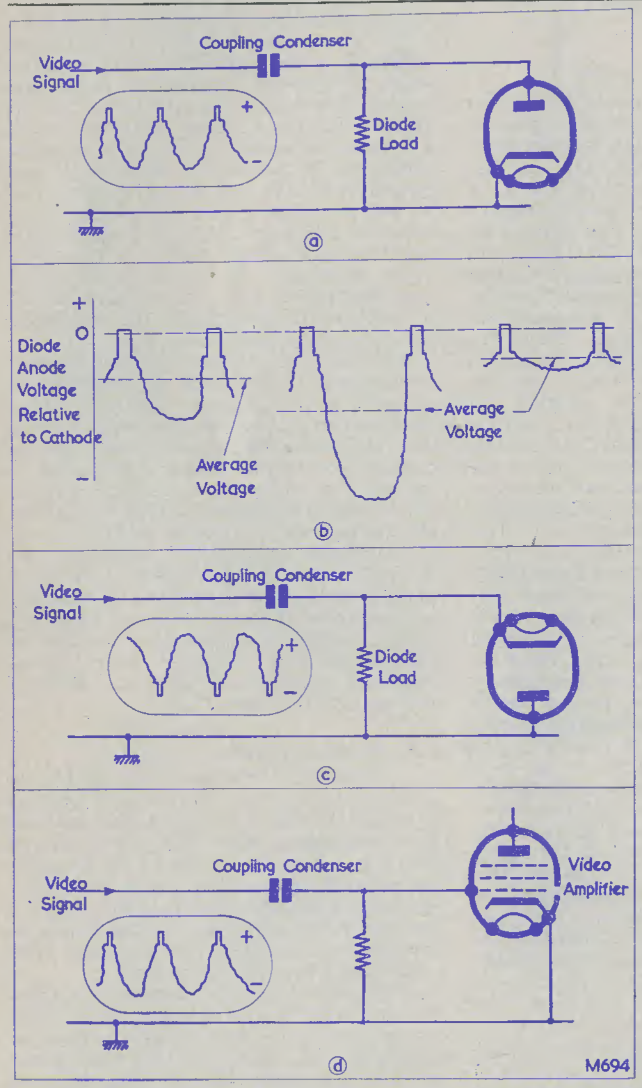


Fig. 120 (a) A d.c. restorer circuit. The restored signal appears on the anode of the diode. (b) The action of the d.c. restorer diode. The positive tips of the sync pulses take up a position slightly positive of cathode potential, thereby causing the remaining parts of the signal to take up their correct positions relative to this potential. (c) When the sync pulses of the video signal are negative-going, the restorer diode has to be reversed. (d) The diode may be dispensed with under the conditions shown here. In this diagram the grid of the video amplifier functions also as the anode of a diode

If the signal applied to the d.c. restorer has negative-going sync pulses, as in Fig. 120 (*c*), it is necessary to reverse the diode in order to obtain the d.c. restoring action.

The restored signal will then appear on the cathode of the diode.

The d.c. restored signal obtained in either Fig. 120 (*a*) or (*c*) is capable of being passed directly to a video amplifier. If desired, it is possible, when the video signal has positive-going sync pulses, to so connect the subsequent amplifier that the diode may be dispensed with. A typical example of how this may be done is shown in Fig. 120 (*d*). In this diagram the grid of the video amplifier functions also as the anode of a diode, whereupon the separate diode valve becomes unnecessary. The arrangement of Fig. 120 (*d*) has the disadvantage that, in the absence of signal, thr valve receives zero bias.

In d.c. restorer circuits handling television signals it is important to ensure that the time constant of the associated condenser and resistances is such that the charge on the condenser drops at a speed commensurate with line frequency. If the condenser discharges too rapidly between sync pulses the inserted d.c. will vary during the period occupied by one line of the picture. On the other hand, if the condenser discharges too slowly the change in restored d.c. level given by a sudden drop in picture information amplitude may not be quick enough for it to pass unnoticed on the cathode ray tube screen. The time constant, when the condenser is discharging, is equal to the capacity of the condenser multiplied by the series combination of the diode load resistor and the resistance of the signal source. This time constant should lie between the period occupied by some five lines and the period occupied by a frame.

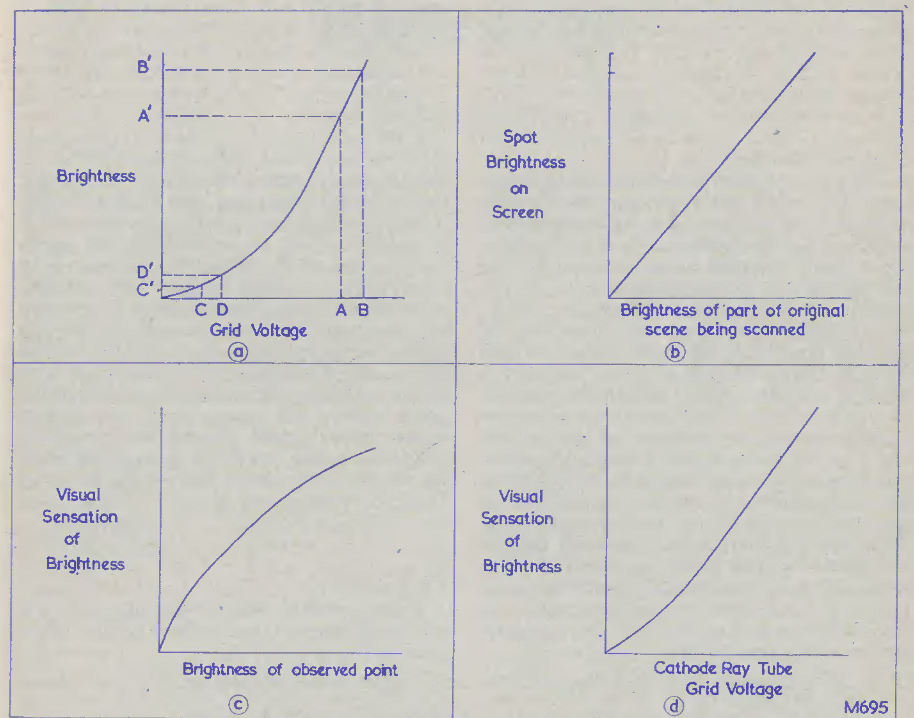


Fig. 121 (a) The grid voltage/brightness characteristic of a cathode ray tube. (b) The ideal gamma characteristic required of a television system. (c) A curve showing, approximately, the relationship between brightness and visual sensation. (d) Combining the curves of (a) and (c) gives this nearly linear characteristic

Gamma

As may have been noticed from the various grid voltage/brightness curves which have been employed up to now to illustrate various facets of cathode ray tube modulation, the relationship between the video signal applied to the cathode ray tube and the brightness of the spot on the screen cannot be represented by a linear (or straight line) characteristic. Instead, we have the typical curved characteristic shown in Fig. 121 (*a*). The amount by which this curve departs from a straight line can be defined by what is known as its *gamma* factor.

It will be seen from Fig. 121 (*a*) that changes in grid voltage cause markedly greater variations in brightness when they appear at the brighter end of the characteristic than when they appear near the black end. Thus, the change of grid voltage between points A and B results in a much larger change in brightness level (points A′ to B′) than does the similar change in grid voltage between C and D (which results in the brightness change C′ to D′).

If the overall television system is to reproduce the scene presented to the camera correctly, it is necessary for the characteristic depicting the brightness of that part of the scene being scanned against the brightness offered by the corresponding spot on the receiver screen to be a straight line, as in Fig. 121 (*b*). (Such a characteristic is stated to have a gamma factor of unity). If this ideal state of affairs is to be achieved it is necessary for some form of compensation to be applied in the overall television system to counteract the gamma factor of the cathode ray tube. It is not usual to provide gamma compensation in the receiver, wherein the video amplifiers normally operate under nearly linear conditions. On the other hand, however, some types of television camera automatically offer partial compensation, by virtue of their principle of operation. It is possible, also, for compensation to be inserted at some point in the video amplifier system at the transmitter.

The characteristic for brightness versus visual sensation provided by the human eye has an appearance similar to that shown in Fig. 121 (*c*), and it may be occasionally stated that the cathode ray tube characteristic of Fig. 121 (*a*) compensates for this, insofar that if the characteristics of Figs. 121 (*a*) and (*c*) are combined, as in Fig. 121 (*d*), we get what is almost a linear cathode ray tube grid voltage/visual sensation characteristic. This statement, however, does not really represent the true facts of the case, because it is the business of the television system to deal in terms of original scene *brightness* (as would be seen by the eye with its inherent gamma characteristic) and reproduced *brightness* (which is similarly seen by the eye with its inherent gamma characteristic). Nevertheless, the fact that the combination of cathode ray tube and visual sensation gamma factors gives a nearly linear characteristic does result in the advantage that the video signals handled by the system (after any compensation which may be applied at the transmitter), are approximately proportional to visual sensation. The instance does not then arise where a large change of visual sensation of brightness level corresponds to only a small change in video signal amplitude level at one end of the range and to an overly large change in video signal amplitude level at the other end of the range. Such an instance would cause small degrees of amplitude distortion at the "cramped" part of the range to be excessively magnified, so far as visual sensation was concerned.

Next Month

In next month's article we shall commence an examination of the timebase section of the receiver.

BOOK REVIEW

PRINCIPLES OF ELECTRONICS (2nd Edition). By H. Buckingham, PH.D., M.SC., A.M.I.E.E., and E. M. Price, M.SC.(TECH.), A.M.I.E.E. 419 pages, 305 diagrams. Published by Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 17s. 6d.

The Cleaver-Hume Electrical Series consists of a number of textbooks written by acknowledged experts in their respective fields; it is also generally accepted that these volumes constitute valuable technical literature for students desirous of widening to the fullest extent their basic knowledge of the various techniques and applications in electrical and electronic engineering. This book is No. 9 in the Series, and its authors are associated with two notable seats of learning for these particular spheres of technology.

Twenty chapters cover subjects ranging from atoms, electrons and radiation to junction rectifiers and transistors. The earlier chapters dealing with the conduction of current in gases and electron emission reveal several basic principles which are often not given the prominence they need for a full understanding of how many electrical and electronic devices operate, and at the same time they lay a sound foundation for an easier appreciation of the applications described later in the book. About a quarter of the book consists of theoretical explanations of this nature; something more than another quarter is devoted to valves, semiconductors, cathode ray tubes, photoelectric cells, etc., while the remainder serves to describe a very wide range of engineering practices which use the methods and devices previously discussed. The text is liberally illustrated with good, clear diagrams. Only a few pages contain mathematical processes, and these are extremely simple.

This latest edition has additional chapters dealing with transistors, and magnetic amplifiers. A few test questions on each chapter are given at the end of the book, and answers to numerical questions are included.

W. E. THOMPSON

Amplified A.G.C. in Communications Receivers

by **J. B. Dance, M.Sc.**

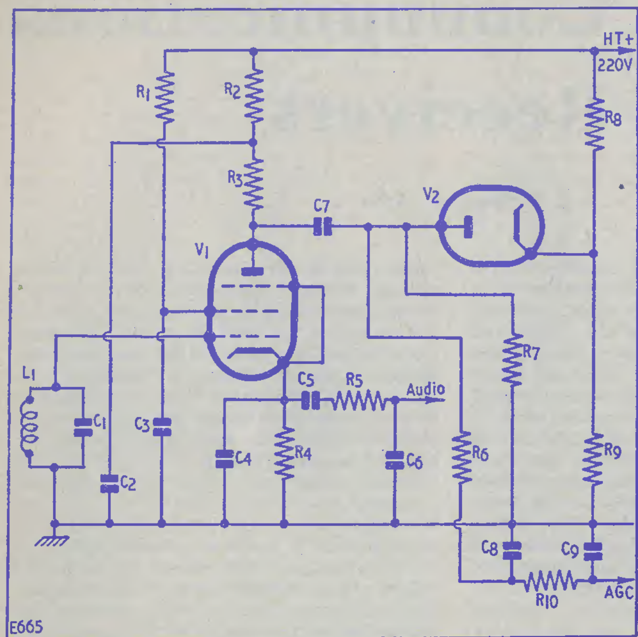
THE SIGNAL LEVELS IN THE VARIOUS STAGES of a large communication receiver must be closely controlled in order to obtain really optimum results. If the degree of control which is desirable is to be achieved automatically over a wide range of input voltages, it is essential to use some form of amplified a.g.c. Economic limitations prevent most manufacturers from incorporating a.g.c. amplifiers in their receivers, but there is no reason why amateur constructors should not use an a.g.c. amplifier in order to obtain the best possible performance. This article describes some practical methods of obtaining a.g.c. amplification which are especially suitable for the home constructor.

The need for amplification becomes obvious when one considers that the number of stages to which the full a.g.c. may be applied is strictly limited. The (first) r.f. stage should not be connected to the full a.g.c. voltage or the resulting reduced mutual conductance will give a lower signal-to-noise ratio at low signal input voltages. If, however, the first valve is left uncontrolled, the following valve will be overloaded if a strong signal is being received. It is not wise to connect the converter grid to the a.g.c. line, as the noise generated by this valve might then become greater than the amplified noise from the first r.f. stage; converters are always noisy valves and increasing this noise may lead to trouble. The application of a.g.c. to a converter may also cause frequency drift if the oscillator is not crystal controlled or if a buffer amplifier is not employed between the oscillator and mixer. There are a number of advantages to be gained from the use of the high selectivity i.f. unit in a double conversion superheterodyne at constant gain irrespective of signal input. The variable bandwidth second i.f. unit used by the author has already been described (*The Short Wave Magazine*, January 1958) and some reasons for operating this particular unit at constant gain were stated. Other advantages of using a second i.f. unit at constant gain are that the second converter always operates at a fairly low level and therefore the possibility of unwanted responses being generated by cross-modulation in this stage is reduced, the signal level is more suitable for the use of a crystal filter and enables the cut-off threshold of a 1st i.f. noise silencing circuit to be more easily controlled by a.g.c.

It therefore appears desirable to amplify weak signals as much as possible in the first i.f. stages and use the first i.f. unit to bring all the signal voltages up to a constant level for feeding into the second i.f. unit; this level should be high enough to avoid any possibility of increasing the receiver noise and low enough to completely avoid any possibility of cross-modulation in the second converter. The full undelayed a.g.c. has therefore been applied only to the first (1.6 Mc/s) i.f. valves. When a signal is being received these valves will operate with a fairly large negative a.g.c. voltage on their grids (up to minus 55 volts on very large inputs) and the effect of small changes in the a.g.c. voltage is therefore very much smaller than if the valves were operating at full gain. If the gain is to be kept fairly constant, an a.g.c. amplifier is almost essential in this type of receiver.

The desired gain may be obtained by further amplification at the i.f. frequency followed by a.g.c. detection, or by using an a.g.c. detector which itself gives gain, or by detection and subsequent d.c. amplification. The last method is more or less eliminated for practical reasons because stable d.c. amplifiers giving much gain are always very complicated. Whilst reasonable results can be obtained by using one extra normal i.f. stage and subsequent a.g.c. detection, the extra i.f. transformer increases the bulk and the amplifier gain is not as great as could be desired. The possibility of the amplifier overloading is greater with this method than with most others. When a very low second i.f. is used an untuned i.f. amplifier could be employed to give considerable gain.

may be attenuated. If the i.f. is 50 kc/s suitable values for C_4 and C_6 are 3,300pF and 1,500pF respectively; if a higher i.f. is used, these values may be decreased in inverse proportion to a minimum of about 200pF. The value of R_8 should be adjusted



R_1 5.6kΩ
R_2 27kΩ
R_3 39kΩ
R_4 100kΩ
R_5 5kΩ
R_6 1MΩ
R_7 1MΩ
R_8 *See text*
R_9 4.7kΩ
R_{10} 220kΩ
L_1, C_1 *Final i.f. transformer*
C_2 0.5μF
C_3 0.1μF
C_4 *See text*
C_5 0.01μF
C_6 *See text*
C_7 100pF
C_8, C_9 *Adjust to produce desired a.g.c. time constant. (About* 0.1μF)
V_1 *Almost any small pentode (see text)*
V_2 VR92, ½ 6H6, ½ 6AL5, *etc.*

Fig. 1. A method of obtaining amplified a.g.c. from a cathode follower detector

Practical Methods

The circuit shown in Fig. 1 will provide amplified a.g.c., but the amplification given by this circuit alone is much too small to be satisfactory; it is, however, useful in combination with other circuits. An additional diode, V_2, is used in combination with the detector, V_1, which is virtually an infinite impedance detector. At the cathode of V_1 the i.f. (but not the a.f.) voltages are bypassed by C_4; the valve therefore gives appreciable gain at the i.f. frequency and the amplified i.f. output is taken from the anode of V_1 via C_7. V_2 detects this amplified i.f. voltage for a.g.c. purposes. V_1 may be an EF91 or almost any small pentode; if the i.f. frequency is not very high, V_1 may be a small triode such as a 6J5, 6C4, etc. The value of C_4 and C_6 required in Fig. 1 depends on the i.f. and on the amount by which the high frequencies to give the required delay voltage. Although the amplification given by this circuit is rather small, it has the advantage that the load imposed on L_1 C_1 is quite small and therefore the selectivity of the receiver will not be appreciably reduced by the addition of this a.g.c. circuit

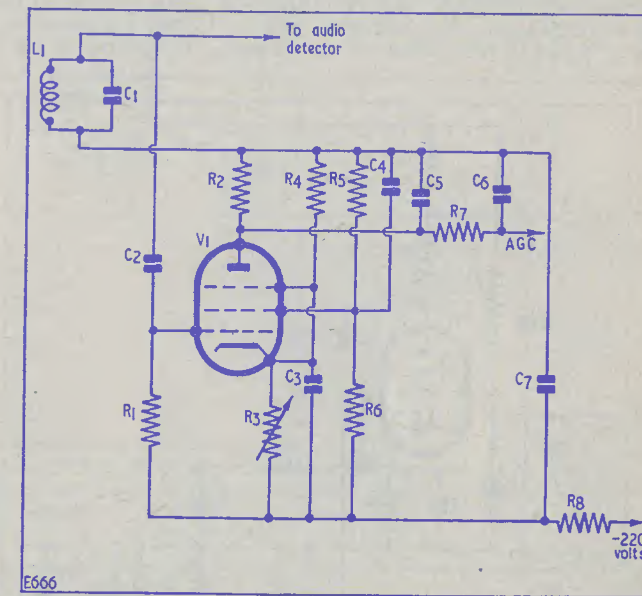
An excellent degree of control may be obtained by using the circuit of Fig, 2. The valve operates in a similar way to an anode bend detector but is biased beyond cut-off under no-signal conditions. A separate detector is required for audio voltages. The a.g.c. amplifier-detector requires an h.t. supply negative with respect to earth; whilst it is possible to obtain this by putting a suitable high wattage resistor between earth and the negative h.t. line from the power supply, the only really satisfactory method is to employ a separate h.t. supply with the positive side

earthed. This may sound expensive but is, in fact, not so (see appendix). When no signal is applied to the grid of the valve in Fig. 2, the anode current must be cut off by the bias developed by R_3 and R_4. It is necessary to use potential dividing resistors to maintain correct d.c. conditions at the

rapidly once the anode current has started to flow and hence this circuit handles large signals very well. The previous i.f. transformer is loaded by C_2R_1; this may be avoided either by using two secondary windings in the last i.f. transformer, one to supply the audio detector and one to supply

R_1 1MΩ
R_2 560kΩ
R_3 20kΩ pot (*preset*)
R_4 220kΩ
R_5 75kΩ
R_6 100kΩ
R_7 500kΩ
R_8 5kΩ
L_1, C_1 *Final i.f. transformer*
C_2 100pF
C_3 0.1μF
C_4 0.1μF
C_5, C_6 *Adjust to desired time constant*
C_7 0.1μF
V_1 EF91, *etc.*

Fig. 2. Amplified a.g.c. circuit employing a negative h.t. supply.

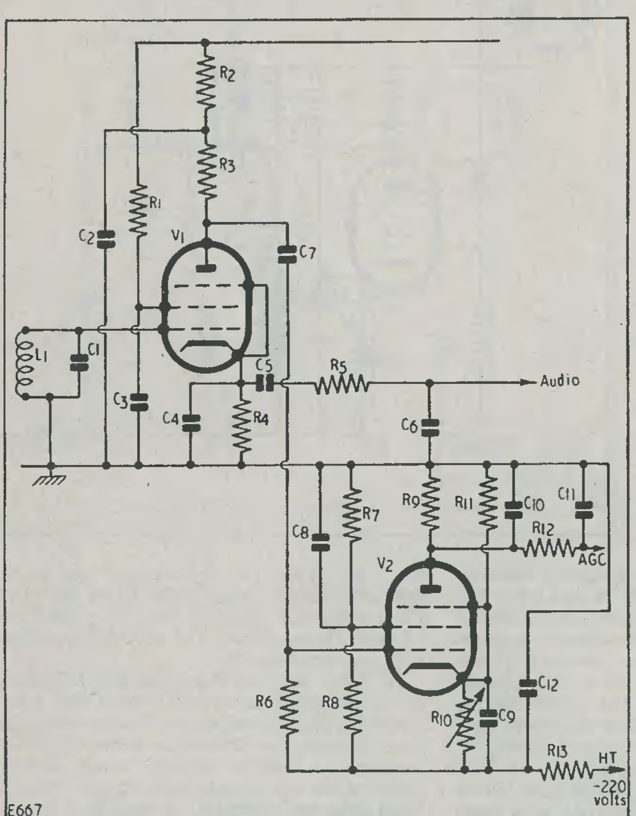


valve electrodes, as single dropping resistors are useless when the valve is cut off. The a.g.c. delay is controlled by the setting of R_3; the adjustment of this potentiometer must be carried out carefully if the best results are to be obtained. The choice of component values is not at all critical, but a valve having a very sharp cut-off should be chosen so that the a.g.c. voltage quickly mounts up on an increase of signal strength; a 6SH7 is excellent in this respect, although most valves which are not variable-mu would give good results. The author has used 6SH7s and EF91s; the circuit of Fig. 2 was designed for an EF91. The screen grid of an EF91 may be used at a higher positive potential than that of many pentodes and if desired the screen grid of an EF91 used in the Fig. 2 circuit may therefore be earthed. A triode could be used in a similar circuit. The gain of the circuit is very large, especially if a high g_m tube is used; if a small alternating voltage is applied to the grid, the anode may become as much as 200 volts negative with respect to earth. The slope of the I_a/V_g curve increases

the a.g.c. valve, or by feeding the audio detector and the a.g.c. valve from the same i.f. transformer winding and using the grids of both these valves at a negative potentia l with respect to earth.

A better method of avoiding the loading of the last transformer by C_2R_1 of Fig. 2 and obtaining a little more amplification at the same time is to use the audio cathode follower detector to amplify the i.f., which is then detected for a.g.c. purposes using the anode bend detector as before. A suitable circuit is shown in Fig. 3; this circuit is really a combination of the circuits shown in Figs. 1 and 2 and gives excellent a.g.c. control.

The circuit shown in Fig. 4 (neglecting, for the moment, the components shown dotted) overcomes some minor objections associated with the circuits of Figs. 2 and 3. In the Fig. 4 circuit, V_1 is not biased quite beyond cut-off at no-signal level; this is better for valve life than the two previous circuits. Whilst using the circuits of Figs. 2 and 3 it was found necessary to considerably increase the bias to completely cut off the last few microamps of anode current; these circuits are not therefore as satisfactory on small inputs as the Fig. 4 circuit, which avoids the possibility of the valve operating on the part of the I_a/V_g curve which has a low slope, i.e. where the anode current is just commencing to flow. In the Fig. 4 circuit there is a negative voltage on the anode of V_1 under no-signal conditions due to the small current which flows through R_4 and V_1. This tends to make the anode of V_2 (and hence the a.g.c. line) negative. The effect of the current over is very sharp. The delay voltage may be adjusted by altering the value of R_8. The value of R_5 also affects the delay, but the value of this resistor is best chosen so that the value of the current flowing through V_1 under various signal conditions is optimum. The anode current should be large enough to allow the valve to work on steep parts of the curve with small inputs, but must not be large enough for the negative part of the i.f. input voltage to be on the straight part of the I_a/V_g curve or the mean anode current will



R_1 to R_5, C_1 to C_7. *Use values shown in Fig.* 1.

R_6 to R_{13}, C_8 to C_{12} *Use value of the corresponding component shown in Fig.* 2.

Fig. 3. *A circuit combining the features of Figs. and* 2.

flowing from the positive h.t. supply through R_8 more than "neutralises" this negative voltage under no-signal conditions and the diode, V_2, is necessary to prevent the a.g.c. line from becoming positive. When a signal is being received, however, the anode of V_1 becomes more negative with respect to earth and this tends to make the anode of V_2 negative. When the anode of V_2 becomes negative the diode will no longer conduct and the a.g.c. line becomes negative. This change-not depend on the input and no a.g.c. voltage will be obtained. A suitable value of the anode current with most valves is of the order of 50 microamps under no-signal conditions. The i.f. input to V_1 of Fig. 4 may be obtained from the last i.f. transformer (as in Fig. 2) or from the anode of a modified cathode follower detector (as in Fig. 3).

A.G.C. for R.F. Stages

The problem of supplying the first r.f.

R_1 1MΩ
R_2 100kΩ
R_3 75kΩ
R_4 560kΩ
R_5 10kΩ pot (*pre-set*)
R_6 220kΩ
R_7 220kΩ
R_8 1.8MΩ
R_9 5kΩ
R_{10} 330kΩ
R_{11} 1.5MΩ
C_1 100pF
C_2 0.1μF
C_3 0.1μF
C_4 *Adjust to produce desired time constant*
C_5 0.01μF
C_6 0.1μF
C_7 0.01μF
V_1 EF91, etc.
V_2, V_3 6H6, EB91, 6AL5, 2 VR91, etc.

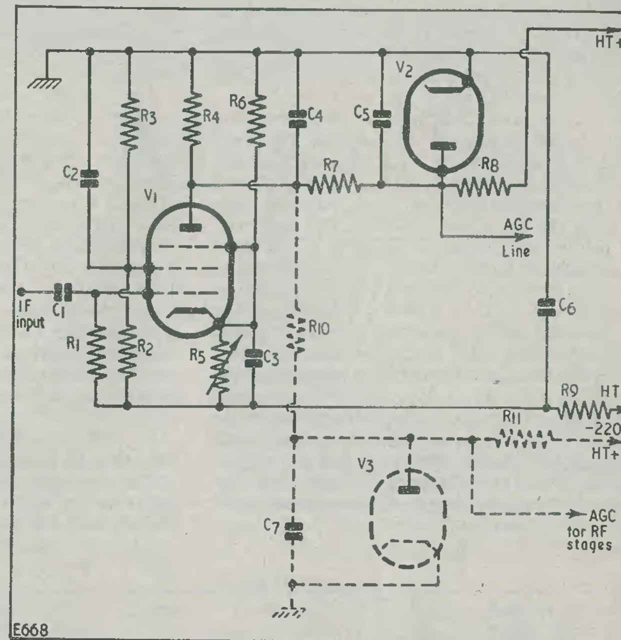


Fig. 4. *Modifications to circuits of Figs.* 2 *and* 3 *which allow V_1 to be used with a small anode current under no-signal conditions. The components shown dotted provide a.g.c. for the r.f. stage(s) with a larger delay than that on the main a.g.c. line.*

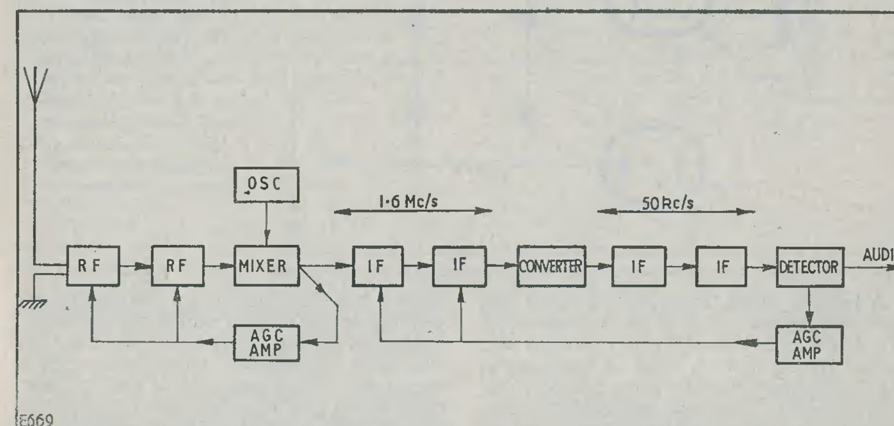


Fig. 5. *Block Diagram of a receiver employing a dual a.g.c. system.*

stages with a.g.c. has already been mentioned. It is desirable (for optimum signal-to-noise ratio) that a.g.c. should only be applied to the r.f. stages when a fairly powerful signal is being received. One good method is the use of a dual a.g.c. system (see block diagram in Fig. 5). The r.f. stages do not receive any a.g.c. unless a fairly powerful signal is present at the first converter. Whilst a dual a.g.c. system is excellent for preventing cross-modulation and achieving the best signal-to-noise ratio, it does need two completely separate a.g.c. systems and it is doubtful if it is worth the trouble of constructing these. Suitable circuits for the amplifiers of a dual a.g.c. system have already been discussed (Figs. 2 and 4).

An alternative method of obtaining the best signal-to-noise ratio when receiving weak signals is to use a circuit which causes the a.g.c. applied to the r.f. stage(s) to have a larger delay than the a.g.c. voltages controlling the i.f. stages. This can be achieved by adding to the circuit of Fig. 4 the extra components shown dotted; it is convenient to use a double diode for V_2 and V_3 (such as a 6H6, 6AL5, etc.). The a.g.c. supply to the r.f. valves can be made less than that to the i.f. valves by any constant amount; the component values shown give an extra delay of about 12 volts to the a.g.c. voltage to the r.f. stages. No a.g.c. voltage is applied to the r.f. valve until the signal strength is great enough to give 12 volts of a.g.c. on the i.f. valves, and the difference between the two a.g.c. voltages is always 12 volts when both are above threshold.

gain is at maximum, but if there should be any cross-modulation, it can be adjusted until the combined bias is just enough to prevent the cross-modulation.

The circuits which have been described give an excellent degree of automatic gain control. It is almost impossible to detect any variation in volume from a receiver using these circuits however much the signal strength may vary above the a.g.c. threshold level when two or more stages are controlled.

The use of an a.g.c. amplifier also makes it possible to take the i.f. output for a.g.c. purposes from the grid of the penultimate stage; if a suitably long a.g.c. time constant is employed, C.W. signals can then be controlled because the a.g.c. amplifier will not be blocked by signals from the beat frequency oscillator.

APPENDIX

Negative H.T. Supply

The most economical way of obtaining a negative h.t. supply is as shown in Fig. 6. The normal h.t. supply of the receiver is not

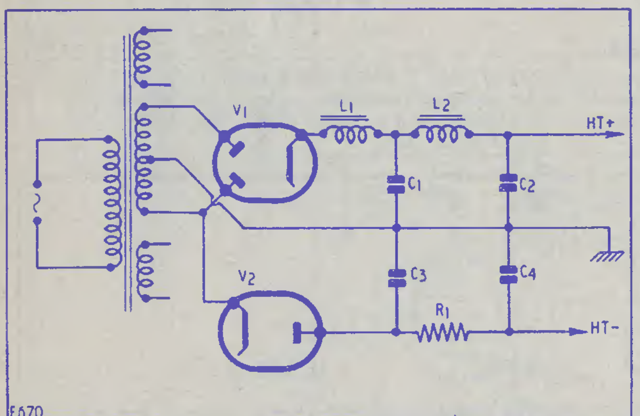


Fig. 6. A method of obtaining a negative h.t. supply. V_1, C_1, C_2, L_1, L_2 and the transformer constitute the normal receiver h.t. supply. The components V_2, C_3, C_4 and R_1 may be added to obtain an h.t. supply negative with respect to earth. For values of the additional components, see text

A receiver using the circuit of Fig. 4 will, however, be susceptible to cross-modulation. If a powerful unwanted signal is present near to the frequency of a weak wanted signal, the unwanted signal will cause cross-modulation at the first converter or elsewhere. Whilst it might be possible to prevent this by the use of a dual a.g.c. system, the strong unwanted carrier within the pass-band of the r.f. stages might cause so much a.g.c. to be applied to the r.f. stages that the wanted signal could not be heard through receiver noise. Perhaps the best solution is to use the circuit of Fig. 4 with a manual gain control potentiometer in the cathode circuit of the r.f. valve. This is normally left so that the

altered but one side of the secondary h.t. winding of the receiver mains transformer is utilised as shown. V_2 is a half-wave rectifier and may conveniently be a 6X5 or, if a miniature valve is preferred, a 6X4, because these valves can be connected to the receiver 6.3 volt heater supply. Alternatively, a metal rectifier such as the Westinghouse type 16HT20 may be used. The current which the negative h.t. supply must provide is only about 3 milliamps under no-signal conditions, rising with input signal to a maximum of about $3\frac{1}{2}$ milliamps; therefore the use of a smoothing choke is unnecessary. Adequate smoothing may be obtained by using 8μF

Continued on page 204

Radio Miscellany

A NUMBER OF INTERESTING LETTERS FROM readers have been received during the month on the subject of learning foreign languages from gramophone records by allowing them merely to "run on" while one gives one's attention to something else. It seems to have worked out in all cases with, of course, varying degrees of success. One reader, who has been cast for a leading role in his firm's amateur Dramatic Club production this winter, thanks me for the suggestion. He is going to record his part and the rest of the dialogue while he is on-stage on a tape-recorder, and is hoping to reduce the spare time required for memorising it by half.

There is much to be learned of how the subconscious mind works. Everyone must have had manifestations of it at odd times; and having a poor conscious memory I must have had scores. We rack our memory to recall a name or a fact, but it seems completely gone. Mysteriously the subconscious gets to work of its own accord and minutes, hours, or perhaps even a couple of days later—wham—up it comes when apparently you are not even trying to think of it. The experience is so commonplace that we have come to take it more or less for granted. The subconscious stores it up for us (although we make no effort to memorise it) and when we want to recall it, it pushes it up to the surface of the conscious mind even though we are not aware we are putting any mental processes into action. Maybe the "memory men" are ordinary people who have gone to the bother of training this particular faculty.

Our old friend G3KPO (ex-Channel Isles, now Peterborough) also found "non-attentive-listening" very effective some years ago when he used it to polish up his rusty French. He even decorated the house and did the gardening while the records ran *ad infinitum*. He warns other amateur gardeners trying this that there is a risk of hearing some good old-fashioned Anglo-Saxon not normally heard in polite Society, superimposed on the foreign language. This would no doubt bring the conscious mind into instant action, which is just as well if you keep it up—there may be an occasional brick to dodge!

From rusty French to rusty tools—G3KPO has found a film of diesel oil is not only fully protective but firmly adhesive, yet easily removable with a wipe of paraffin or petrol. For penetrating power and cleaning qualities (apart from its lubrication value) he adds that 3-in-1 oil is to be highly recommended.

While Workers Sleep

I am afraid I once again have to plead a poor month (in health) for what must be a scrappy column. Much of the time I have been able to sit up in the old armchair and watch TV whenever the programmes seemed sufficiently attractive—which was a lot less frequently than was desirable.

People who want round-the-clock TV always stress the supposed needs of the sick and bedridden to bolster their case. In the last couple of years I have become quite an experienced invalid and, believe me, those dreary, time-filling programmes merely irritate or depress, both of which are bad things even for those in good health. True, the B.B.C. have put on a few worthwhile items lately, but they seem extremely shamefaced about doing it. They tack them on at the end of the evening when viewers who have to go to work next day are really past their bedtime. Perhaps our timid programme planners have decided it's better late than never—it isn't, at least not that late!

In the Dark

This column recently prodded the Ministry of Supply for failure in adequately publicising a recent exhibition which would have attracted many of our readers. Undeniably the Ministry did think of us—but the "advance news" they sent was dated only four days before it opened. Although the exhibition ran for a month, it was obviously far too late for us to pass the news on in time.

It now seems the Ministry were much more secretive about it than I first thought.

I have since learned from a reader (who must remain anonymous) that he didn't hear about it either until it was all over—and he works for 'em!

Bigger and Cheaper?

I had to miss out on the Radio Show at Earl's Court due to bedfastness, but I cannot pretend that I found this much of a hardship. It has long since become little more than a furniture exhibition. Whatever innovations there may be are carefully concealed under the highly-polished cabinets, and one can seldom find anyone on the stand with any technical knowledge.

A kind friend brought an enormous bundle of literature to my bedside (all of which was completely uninformative from my point of view), and a lengthy eye-witness account (which was entirely from the ordinary viewer's angle). The highlights, I gather, were tape recorders (more makes and models than I realised priced between £25 and £30), and transistor receivers which aren't much different to the old models (which seem to be a little cheaper, now in the region of £20).

that only a tiny proportion of them come into the "intermediate" category. There are plenty of the "radio-made-easy" type for the raw beginner and even more for the advance worker and the specialist, but precious little for the man out of the beginner stage, but not up to the advanced stuff. Publishers, please note! It is likely he is right. I had a deuce of a job finding a few recommendations for him. By the way, I said his was a nice letter. Perhaps my judgment was influenced by the fact that he said he not only likes this column, but it is the first thing he looks at each month!

Funnily enough, G3KPO (see above) also says he likes it, but it is the second thing he looks at!

The first? Believe it or not, the Readers' Small-Ads. Maybe quite a lot of folk make a point of scanning these Small-Ads. straightaway so as to be early in the field for any special bargains. It would be rather interesting to take 100 readers and find out what they look for first. No doubt quite a percentage take it as it comes and merely flip over the pages until something catches their eye, but undoubtedly many have got

Centre Tap talks about items of general interest

My friend was very much impressed with the "slim" TV receivers using the 110° tube, but these are no longer a novelty to most. He felt the prices (17in sets at £70) was proportionally much chéaper than the cost of a 9in set of ten years ago. True, prices of other things have risen sharply during that time, but I well remember Pye's doing a table model about that time for 38 guineas and other manufacturers hitting equally low prices—and that was long before printed TV circuits.

I don't think I changed his opinion, but I was too weak to think (even with the subconscious mind) of what the purchase tax was in those days. So it all seemed rather pointless and I must have rudely fallen off to sleep while my visitor was still talking—at least I don't remember saying "Good-night". Anyway, on a present-day set costing £70 the tax would be about £20—a fact we might have discovered from a few of those uninformative lists if we had only thought of looking.

That First Look

In a nice letter from E.P. (Marlborough), he says he has been checking on the very large number of books on radio and kindred subjects, and has come to the conclusion "favourite" features.

While there is always quite a number of Small-Ads., I have often wondered why this department is not even more widely used. Is it that everyone has so much money nowadays that they can afford to discard their surplus gear as they finish with it?

Actually, of course, readers' ads. are run at a loss to the magazine, which is really immaterial as editorially they are regarded as a reader service. We rate reader goodwill very highly and there is no point in making a helpful (and interesting) feature self-supporting at the risk of diminishing the popularity of this particular service.

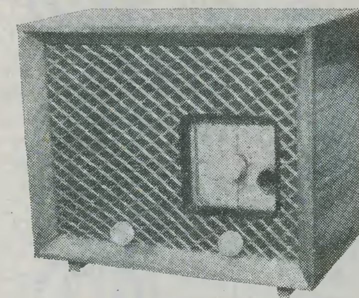
Human Rights

In common with all licensed amateurs throughout the world, I am anxiously awaiting the outcome of the four-month conference (at Geneva) on frequency allocations. It seems, as usual, that every user of the "ether" is claiming more space, and there are now new and strong claims such as for space rocket control, "blips" and data communication

The tiny parts of the spectrum allocated to amateurs have, over the years, been whittled down at each succeeding conference,

Continued on page 209

The PREFECT SUPERHET 6 RECEIVER



by A. S. CARPENTER

A straightforward design that even the novice may tackle with confidence

Let it be said straight away that this receiver is one of the oftimes disparaged four-plus-ones. No apology is offered—none is needed. This type of receiver has stood the test of time: it is reliable, efficient, more trouble-free than is often the case with more ambitious designs, and comparatively inexpensive. Also it is an arrangement generally favoured by manufacturers.

If you have not yet ventured into superhet circuitry, fearing that "lining up" will prove an insurmountable barrier, have no fear. If you have no signal generator, and have not access to one, you could, when you have completed construction, take the chassis together with the circuit diagram to a serviceman. Some of the smaller concerns are run by men who were themselves amateurs once, and for a nominal charge they will be only too glad to do the necessary vetting. To illustrate: two chappies (neither of whom knew the slightest thing about radio gear) bought a large amplifier kit and wired it up from the drawings, using an old-fashioned soldering iron heated in the fire. On completion they took it to a co-operative dealer. He complimented them—only one wire was wrongly placed and that he soon fixed. Readers are therefore encouraged to proceed with confidence.

The efficiency of the receiver about to be described is due mainly to the fact that at its heart lies a really efficient coilpack. In a superhet of any kind the tuning components are of first importance; those specified therefore are a *must*. The constructor, however, is given some choice. He may either

(*a*) purchase the separate coils and the basic coil-pack assembly and make the pack up himself, or

(*b*) he may purchase the coil-pack ready made and aligned, in which case it will only be necessary to make a few connections from it to the external circuit.

Further, he is given a choice of wavebands. The receiver described covers the Medium and Long wavebands; in some situations the latter might not be necessary, in which case coils L_2, L_4 (Fig. 1) can be changed for one of the short wave ranges. There is a dial available to suit either. More information regarding the coil-pack will be given later in the article, but it is pointed out that many advantages are derived from using a proper pack. This one measures less than 6½ square inches and contains four coils, four trimmers, two fixed capacitors and a wave-change switch! Wiring is thus kept short and direct—a point of some importance. And remember, once you have it it can be simply and easily removed at any time!

No receiver if it is to look professional can afford to be without an artistic cabinet, and Lewis Radio Ltd., have designed the attractive model illustrated. The escutcheon is supplied with the dial.

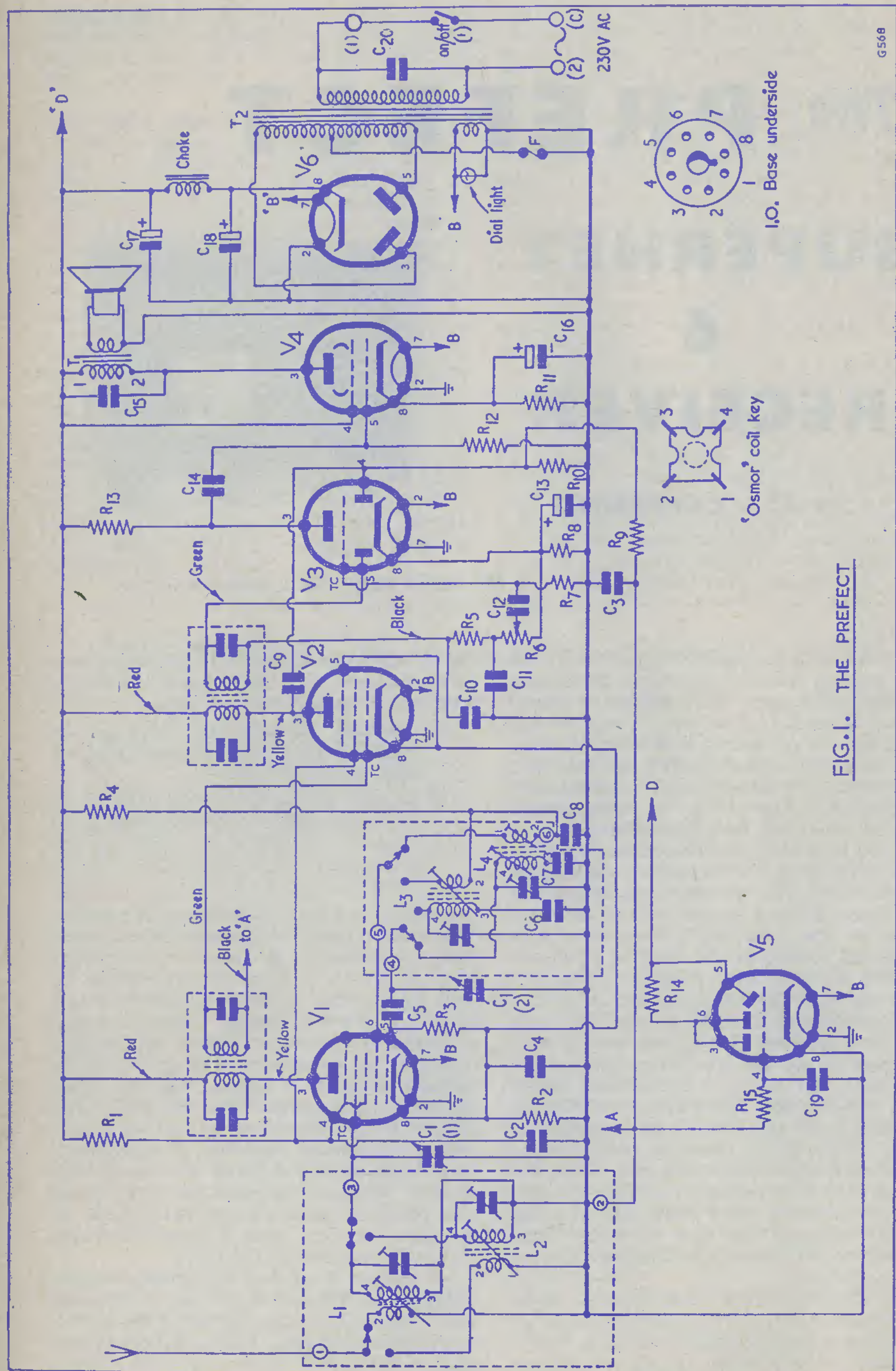


FIG. 1. THE PREFECT

Note: The connection from Tag 2 of the coil pack should not go to chassis as shown, but should "cross over" and connect only to the junction of Tag 3 of L_2 and the trimmer

As can be seen from the photographs, a "magic eye" tuning indicator is fitted, the screen being visible through the bottom right-hand side of the dial looking from the front. It is arranged to fall in the Long wave section so that needed station names are not obliterated. The dial specified is a metal type and matches the coil-pack, and to accommodate the indicator a hole is drilled in it which becomes the front support for the indicator. Its base is supported on the chassis by a small L-shaped bracket. The drive mechanism for this dial normally consists of a drum, cord, drive and spring, but this has been dispensed with and centre tuning employed. To obtain slow motion an epicyclic drive is fitted.

Some constructors might prefer not to incorporate the tuning indicator. This is quite permissible, and in this case V_5, R_{14}, R_{15} and C_{19} should be omitted. Its inclusion, however, is well worth while as it is not only a good aid to lining up but is also useful in letting one know that the a.v.c. is operating. Unskilled operators will also find it extremely useful for normal tuning-in adjustments. A point that must be emphasised is, that if the "eye" is included, C_1 (the twin gang capacitor) must be a really midget component, otherwise the moving vanes will foul the indicator. A bathtub type such as is used in the original is preferable, although one in which the vanes move in the direction opposite to the indicator position should be satisfactory.

Chassis space is not unduly limited, but can be increased by using miniature components for the smoothing choke and the output transformer.

The more modern miniature valve types were considered at first for use in this receiver, but octal types were eventually chosen so that constructors could take advantage of the cheap and plentiful supply. The i.f. transformers, too, are standard

COMPONENTS LIST

Resistors
- R_1 33kΩ
- R_2 220Ω
- $R_{3, 4, 5}$ 47kΩ
- R_6 500kΩ pot. and single-pole switch
- $R_{7, 9}$ 2.2MΩ
- R_8 4.7kΩ
- $R_{10, 15}$ 1MΩ
- R_{11} 470Ω, 1 watt
- $R_{12, 14}$ 470kΩ
- R_{13} 680kΩ
- (All ½ watt except where stated.)

Capacitors
- C_1 500pF twin gang midget (see text)
- $C_{2, 3, 4, 8, 12, 14, 19}$ 0.01μF, 250 volt
- $C_{5, 9, 10, 11}$ 100pF mica
- C_6 470pF (see text)
- C_7 150pF (see text)
- C_{13} 25μF, 12 volt electrolytic
- C_{15} 0.006μF paper
- C_{16} 50μF, 50 volt electrolytic
- C_{17} 24μF 450 volt electrolytic
- C_{18} 12μF 450 volt electrolytic
- C_{20} 0.1μF, 1,000 volt

Coil Pack

Osmor 2-waveband, Type LM, complete. Or basic assembly unit and separate coils (see text).
- L_1 Osmor QA 81
- L_2 Osmor QA 91
- L_3 Osmor QO 8
- L_4 Osmor QO 9

} or ranges as desired (see text)

Dial

Osmor 2-waveband metal type (ranges as desired, see text)

I.F. Transformers

Osmor, 465 kc/s, standard

Valve Holders

Octal (International) McMurdo

- T_1 Ellison, OP62
- T_2 Ellison, MT161

L.F. Choke

Ellison, TC30

Chassis

16 s.w.g. aluminium, 10in x 6in x 2in, four-sided

Cabinet

Lewis Radio Ltd, Green Lane, London, N.13 (see text)

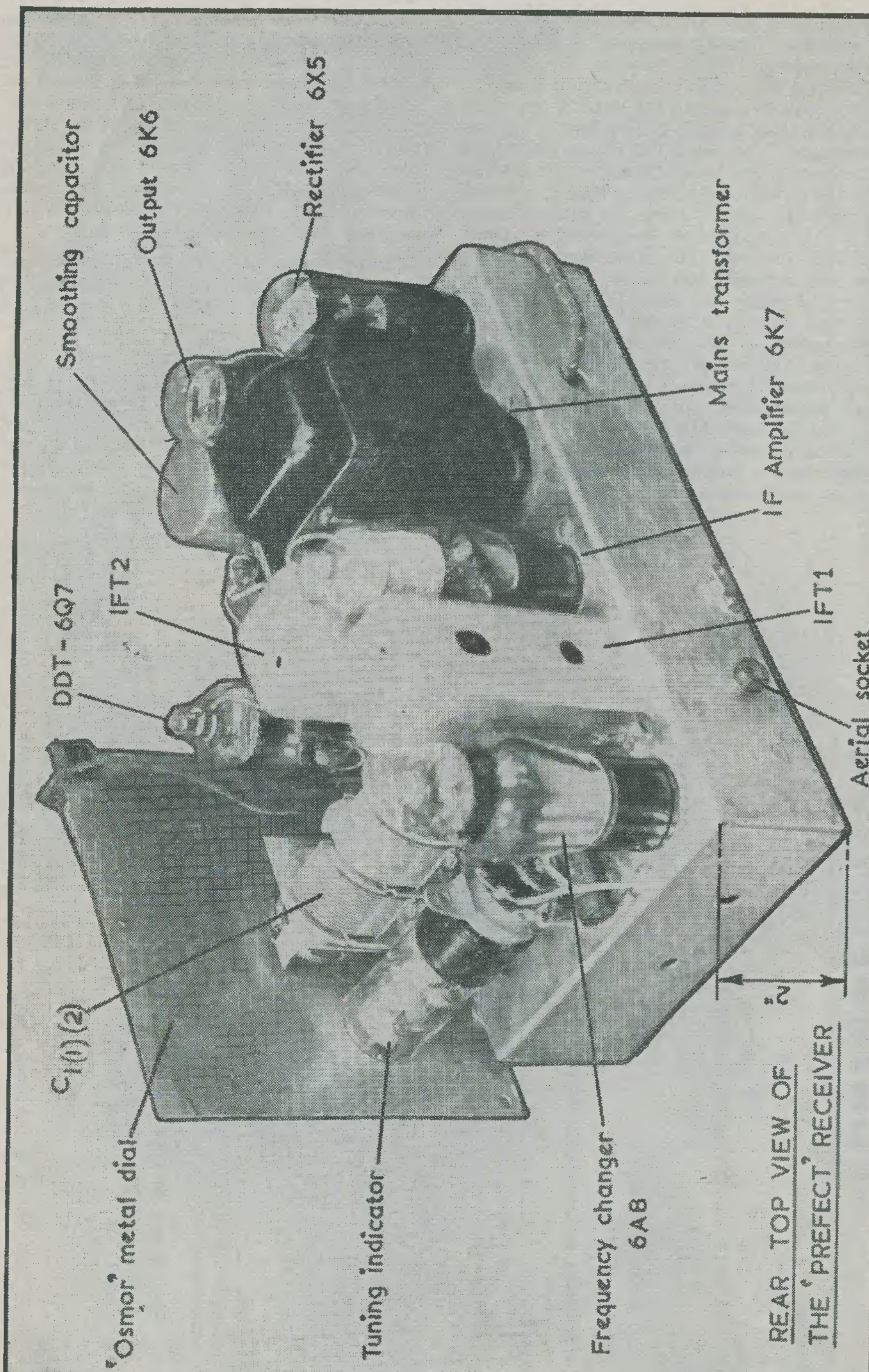
Valves
- V_1 6A8
- V_2 6K7
- V_3 6Q7
- V_4 6K6
- V_5 EM34
- V_6 6X5

Speaker

Truvox, 5in.

Miscellaneous

Three octal valve top caps, nuts, bolts, solder tags, connecting wire, mains plug, L-shaped bracket for V_5, dial bulb and holder, epicyclic drive, pointer, fuse, aerial socket, mains input flex, 2-connection tagstrip, electrolytic capacitor fixing clip, etc.



REAR TOP VIEW OF THE 'PREFECT' RECEIVER

types, being physically more robust than many of their miniature contemporaries.

The Circuit

Consider Fig. 1. The circled figures indicate the tags on the coil-pack: for example, No. 1 tag is connected externally to the aerial socket. For tag identification see Fig. 3. The dotted lines in Fig. 1 indicate those components contained in the coil-pack and i.f. transformers. V_1 is the frequency changer which provides an intermediate frequency of 465 kc/s at its anode, and this is fed to V_2, the i.f. amplifier via the first i.f. transformer. (Note that the coloured leads are indicated on the diagrams.) V_2 amplifies the i.f. then passes it on to V_3, where one diode demodulates it. After filtering, the resulting audio is fed to V_3 grid and thence to V_4 for amplification. The volume control is the diode d.c. load resistor, and to avoid distortion R_7 (which together with R_5, R_6, forms the a.c. load) is made four times larger than R_6. Note that the bottom end of this resistor is connected to V_3 cathode which is held at 3 volts positive with respect to chassis due to the voltage drop across R_8 when the valve is conducting. This provides the a.v.c. delay voltage as D_2 (the a.v.c. diode) has its load resistor connected to chassis and is therefore 3 volts negative in respect to the cathode. D_2 cannot conduct, therefore, until the peak i.f. exceeds the delay voltage. The a.v.c. coupling capacitor (C_9) must be a high quality component as any leak, however small, will upset the a.v.c. arrangements. The a.v.c. is fed back to the grids of V_1 and V_2 and also to the tuning indicator.

"The Magic Eye"

For those who are not familiar with this type of indicator it may be said that under "no-signal" conditions V_5 exhibits "traces" separated by wide blacked-out areas or shadows. When a voltage negative with respect to chassis is applied to the grid the shadow areas decrease. A very powerful signal might even completely remove the shadows, and if one rotates the main tuning control the shadow will decrease as each station is passed. All one has to do then is tune for minimum shadow for each particular station.

The Power Supply

The power supply consists of an isolating transformer (T_2) and its associated components, and full-wave rectification is employed in conjunction with a 6X5 rectifier. An Ellison transformer is specified (but is not included in the original) and this has two 6.3 volt windings (in addition to the normal input and secondary windings) but only one of these is used. The rectifier has a separate cathode and its heater can be supplied from the normal l.t. winding as is shown on the diagram. However, as one side of this winding is connected to chassis a heater/cathode short occurring in V_6 can be disastrous, as its cathode is positive by some 250 volts. (A burnt-out choke could raise this figure still higher.) Adequate safeguards must be provided and so the fuse (F) *must* be included. A torch bulb may be used, but a proper fuse is recommended. The on/off switch in the mains transformer primary is included with the volume control potentiometer. If desired the rectifier heater may be fed from the second l.t. winding on T_2, but in either case the fuse should be included.

Construction

First cut and drill the chassis and mount the components to conform with the diagrams (Figs. 2, 3 and 4). Point-to-point wiring is also shown but should be ignored at this stage. The dial is bolted at its base to the front edge of the chassis and held off by two ½in spacers. Tentatively mount this together with the twin gang, remembering to leave sufficient space for the tuning indicator. When the dial is secure, V_5 can be plugged into its base and held in position while a line is drawn round its end on the back of the dial. Now remove the dial and cut out, either with a tank cutter or an Osmor jiffy punch, taking care that metal cuttings do not scratch the front. It is best to cut the hole slightly smaller than is necessary, enlarging it with a circular file a bit at a time till the tip of V_5 fits snugly. The dial may now be refixed, also V_5, the top of which should not project through more than ⅛in. No difficulty should be experienced with any of the remaining components. With an aluminium chassis fix a solder tag to each valve retaining bolt. The i.f. transformers are easily fixed as they carry lattice holes and ordinary wood screws are inserted into them from below chassis. Ensure that IFT_1 is positioned with the cores visible from the rear. The cores of IFT_2 should face the tuning indicator otherwise they will be inaccessible for lining-up adjustments later. There is only one tagstrip (two tag type) and this is situated close to the choke.

The Coil-Pack

Before proceeding with the general wiring it is advisable to get the pack ready. If you decide to buy it ready made, nothing further requires to be done to it with the exception of making the external connections; and those who purchase the basic assembly unit and separate coils (which are of the half-cupped variety giving increased "Q") will find that most of the wiring is already done. C_6 and C_7 will be found *in situ* and connected at the earthy end as will be the four trimmers, one

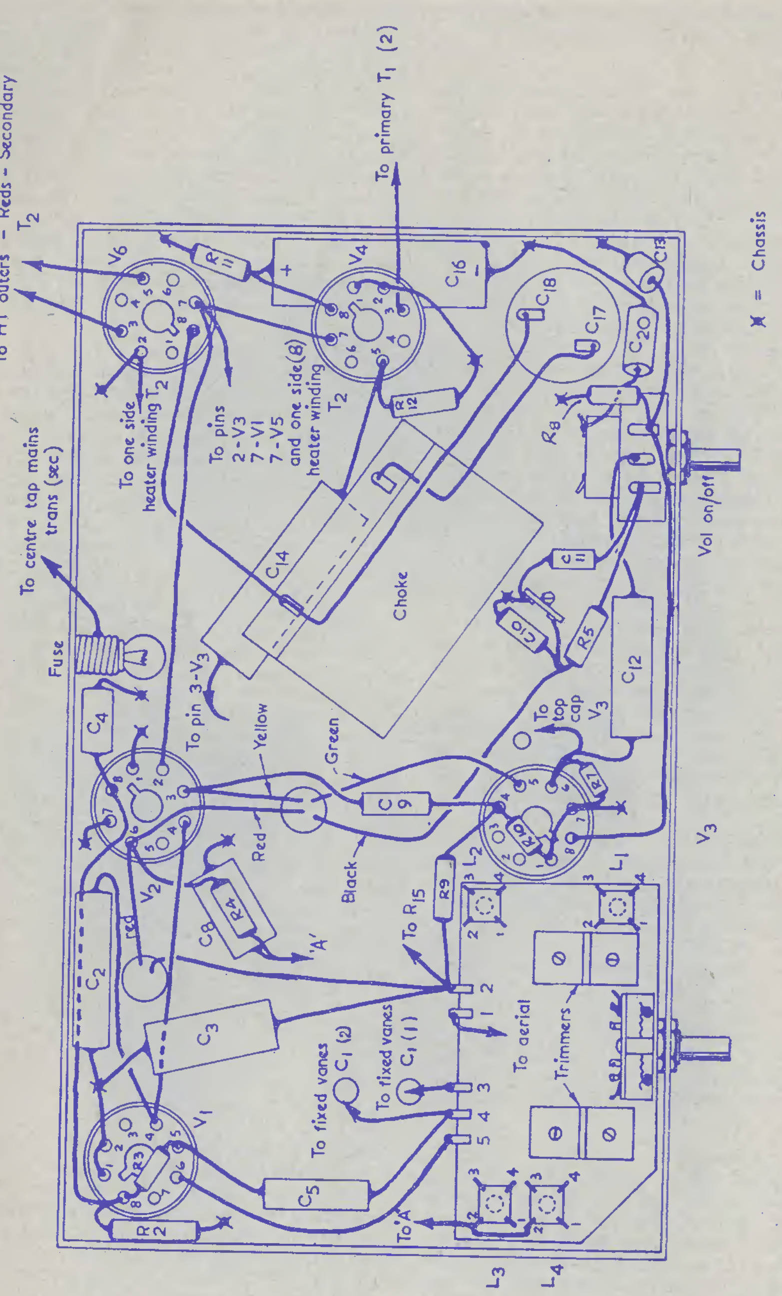


FIG. 3. THE PREFECT ~ UNDERSIDE WIRING ~ 1ST STAGE

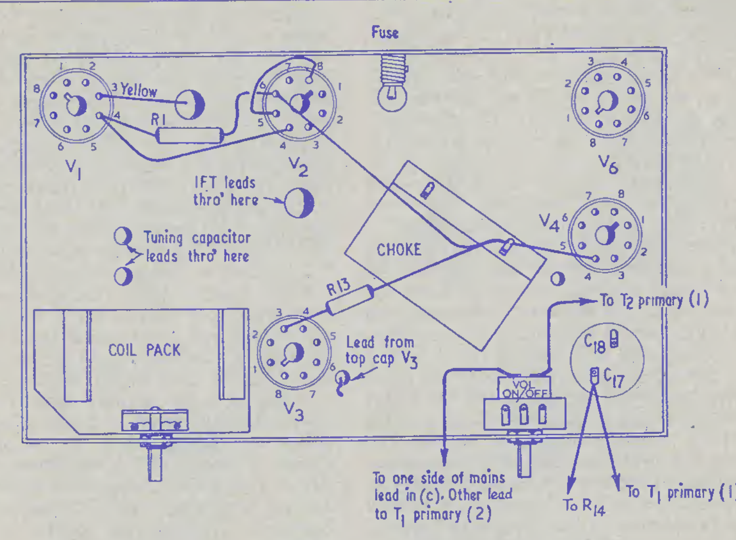
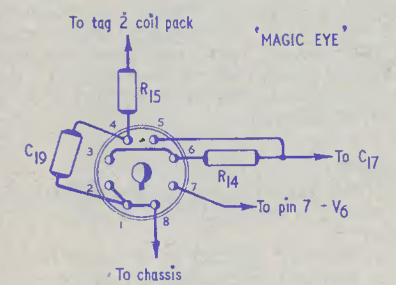


FIG. 4. 'THE PREFECT'- UNDERSIDE WIRING - 2ND STAGE



ABOVE-CHASSIS CONNECTIONS

Top cap V_1 to fixed vanes C_1 (1)
" " V_2 to green lead at top of IFT1
" " V_3 to pin 6 of V_3
One side primary T_1 to C_{17}
" " " " " pin 3 of V_4
" " secondary T_1 to LS and one side to chassis
Fixed vanes C_1 (2) to tag 4 coil pack

FIG. 5.

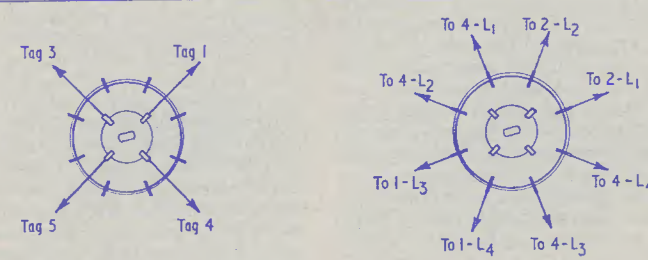


FIG. 6. CONNECTIONS TO ROTARY SWITCH

If a 3-way type, ignore 1st way tag in all cases except where the pole goes to tag 3; connect this one to chassis

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pair carrying yellow leads and the other pair blue leads which are already soldered to the switch. A further capacitor of 2,500pF might be discovered; if so, it should be removed. Its inclusion was intended for bottom-end coupling, but as we are using an aperiodic coupling we do not need it. The four coils should be inserted in the holes provided (see Fig. 3) and connected up as shown in the circuit diagram. The four "poles" of the switch are at its centre, while the "ways" are at its rim. Fig. 6 shows the connections.

Six outlet tags are needed and only five are included, therefore either add another or solder a flying lead to both tags 2 on the oscillator coils. All soldered connections to the coil tags should be made very carefully: use a hot iron and hold the tag firmly with a pair of thin-nosed pliers to bypass the heat. Excessive heat will soon bring the tag adrift from its moorings in the holder. A certain amount of patience is needed to wire the pack; but it is not an unduly tedious business, rather one that requires to be done slowly to avoid confusion. On completion it should be loosely inserted in the chassis to see that it is not fouled in any way, then placed to one side.

The main chassis wiring can now be proceeded with and Figs. 2, 3 and 4 will help with the underside, while Fig. 5 shows the "magic eye" connections. Commence with the heaters, proceed to the power supply and leave the larger capacitors till last or they will get in the way. Some of the wiring is shown on one diagram and the rest on the other.

Slight re-arrangement of components is unimportant—where a chassis connection is indicated, for instance, it will probably be easier to move the position of a resistor, etc., slightly for convenience. This is quite in order; the constructor will appreciate that drawing point-to-point diagrams has problems of its own and therefore "cross-overs" appear more frequently than are absolutely necessary. Note that on V_2 and V_3 pins 2 are the live heater pins, whereas on all other valves pin 7 is the live one. It doesn't matter in the least and is arranged so for ease of wiring. Incidentally, you will find that using wires with differently coloured insulation will considerably assist you when the time comes to check it all over. Insert the coil pack and secure firmly by means of the bolt provided on the switch which, incidentally, also provides the necessary earth or chassis connection so obviating a separate earth tag. Finally, make the six external connections to the pack.

Testing

When the wiring has been completed the receiver is ready for test. Impetuosity must be restrained at this point and the mains plug left out of its socket!

First check all wiring carefully. If O.K., connect the negative test prod of an ohmmeter to chassis and apply the other to pin 8 V_6. Do not be alarmed if the needle swings over to zero and creeps back slowly—the charging of the electrolytics is doing that for you! If the needle remains at zero, however, something is wrong with the wiring. If O.K., insert valves and repeat this check. Next prod the valve grids in turn to make sure each is connected to chassis—all these readings will be high. Clip negative prod to pin 8, V_6 and obtain a reading at each valve anode (except V_6), screen, and the oscillator anode of V_1. Return negative prod to chassis and obtain a reading from pins 3 and 5, V_6 and ensure that no reading is obtainable from these when the fuse is removed. Ensure that no reading is obtainable from either side of mains plug to chassis with switch open or closed. Connect meter prods to mains plug pins and obtain a reading when the on/off receiver switch is closed and none when it is open. Check the heater wiring, and remember you will get a reading even if the valves and dial light are removed due to the l.t. winding on T_2.

If all is well, the mains plug may now be inserted and the set switched on. See that all valves are lit, then check h.t. from one side of the choke to chassis: it should be around the 250 volts mark, depending on the goodness of your meter. Turn volume up and touch the aerial socket with a screwdriver. If a loud click is obtained your set is working and only requires lining up.

Aligning

If you have a signal generator, carry out alignment in the usual way. If not, you may either

(*a*) take the receiver to a friend or to a dealer as mentioned earlier, or

(*b*) attempt aligning by trial and error.

The latter is not impossible; it is extremely unlikely that you will achieve the correct i.f. frequency; but quite satisfactory results *can* be obtained if one has sufficient patience.

If you intend to do this, see before you start that the cores of the i.f. transformers are reasonably well in, then rotate the twin gang (with an aerial connected). Locate any station, but preferably a B.B.C. transmission. It will be very weak, probably, but never mind. Now peak it up, starting with IFT_2 secondary and working backwards, finishing with IFT_1 primary. Go back over this several times until no improvement can be made. Now try and identify the transmission and bring it to the correct point on the tuning scale by means of the core of either L_3 or L_4 depending on which band you are using.

The next stage must be carried out on the Medium waveband. Tune in a station at the

high frequency end of the scale and adjust the trimmers of L_1 and L_3. If no optimum point can be found, tune to a slightly higher frequency and try again. Now select a transmission at the other end of the scale and peak it with the cores of L_1 and L_3. Repeat these two operations several times until no improvement can be made, then do exactly the same thing on the other band. (*Note:* if initially you cannot obtain a station to work on, try setting the twin gang midway on its travel and turning the core of L_3. On no account use a metal screwdriver for trimming adjustments.)

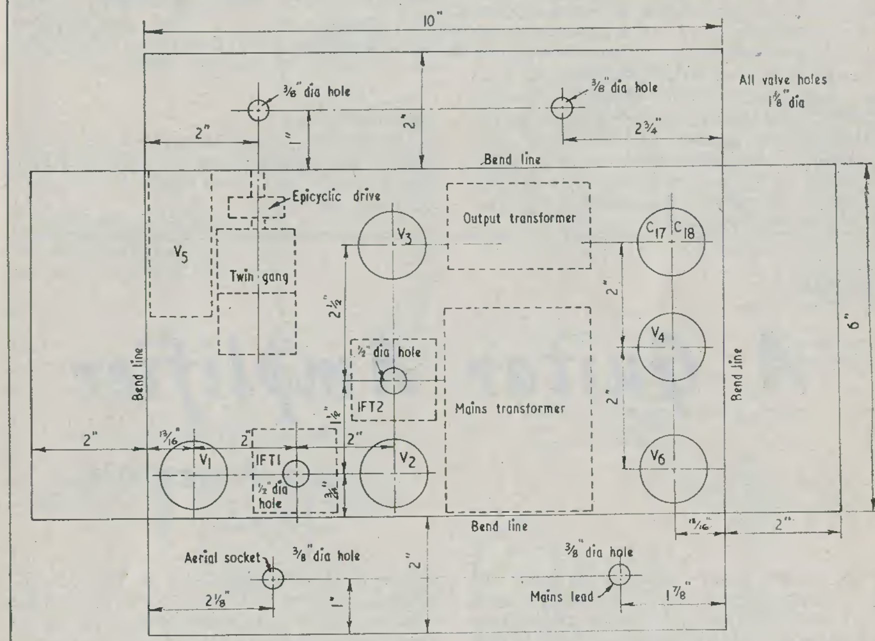


FIG. 2. THE 'PREFECT' – CHASSIS DETAILS

During the latter stages the tuning indicator will prove of immense value as a visual guide, and only when you have observed the difference a fraction of a turn of a core or trimmer can make will you realise how insensitive the ear is to slight changes. Remember, however, that trimming IFT_2 secondary will have no effect on the indicator as this is not in its circuit, being fed from the primary winding of IFT_2.

As a final adjustment, the i.f.t. secondaries can be detuned slightly to improve quality.

General

An EM34 is specified for the indicator. In the original a 6AF7 is used, but as this does not appear in surplus valve lists the reason for the change is obvious; the base connections, however, are identical.

Changes in component values, especially resistors, will materially affect the performance. Valve types, too, are important. You might argue that a 6V6 could be used for V_4—the base connections are the same. But compare the total (anode plus screen) current! The mains transformer gives you 60mA, and when a 6V6 has had its ration not much is left—so down will go the h.t. rail voltage; the lower the current demanded the higher the voltage offered—within limits, of course.

Instability in the form of i.f. regeneration might show itself if the cores of L_1, L_2 are too far in. They are intended to operate on the secondaries, which are at the top of the formers. Screwed in, they will tend to couple the primary to the secondary. Instability might be due to the screen of V_2 and a 10kΩ 1-watt resistor from pin 4 of this valve to chassis will rectify the trouble.

Variation of tone can be achieved by increasing the value of C_{15}, and if desired a 100kΩ potentiometer connected in series with a 0.01μF capacitor across T_1 primary would form a variable control. No provision, however, has been made for this on the chassis.

An earth socket may also be fitted if desired.

External Equipment

Those who wish to add either pick-up sockets or external l.s. sockets, or both, may do so by mounting a suitable paxolin socket block at the rear. In the case of the former, all that is necessary is to connect one pick-up socket to chassis and the other to the top end of the volume control potentiometer via a length of screened lead. A suitable lead can be made by cutting strips of thick foil, such as is sometimes used for packing tobacco, and winding it tightly round the whole length of an insulated wire of, say, 20 s.w.g. The foil should be earthed to chassis at both ends. If a 3-way switch is included in the coil pack (as already mentioned) the third position can be used for gram to short the aerial to chassis. Alternatively, a small toggle type switch may be fitted alongside the pick-up sockets for aerial shorting purposes.

Connections for an external speaker consists merely of taking a lead from each of the output transformer secondary terminals to the l.s. external speaker socket pins.

Conclusion

Providing the specified components are used and the design adhered to, first-class results are guaranteed. The author is always willing to help constructors who comply with the above directions.

Finally, don't forget the cabinet. "Why spoil the ship, etc. . . ." Not only will you have an efficient radio receiver—you will also have a handsome piece of furniture.

Appreciation

The author wishes to express his sincere thanks and appreciation to Osmor Radio Products Ltd. and Lewis Radio Co. for their technical assistance.

AUDIO

A Guitar Amplifier

By **G. F. WEBSTER**

THE CONSTRUCTION SHOULD BE MADE ON a metal chassis and in a way that will keep the input circuit wires as short as possible and away from the rectifier. If this is done, the general layout can be as desired.

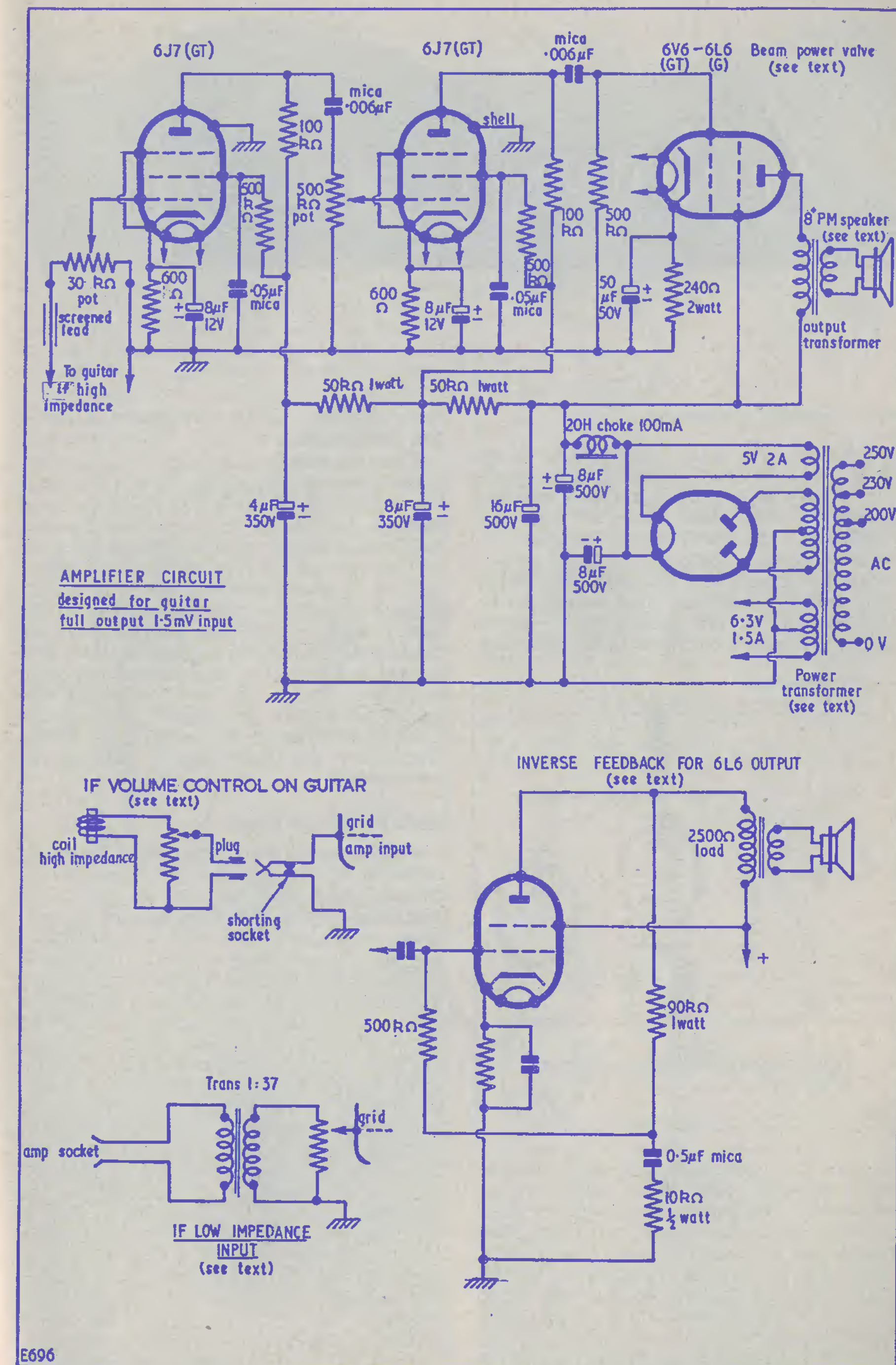
Instability may be caused if the component values given are changed or the decoupling filters omitted. The secondary of the mains transformer will be required to supply 250–0–250 volts at 60mA if the 6V6 beam power valve is used, also 5 volts at 2 amps. and 6.3 volts at 1.5 amps. For the alternative output with the 6L6, the supply required is 300–0–300 volts at 90mA; also a change of value is needed in the cathode bias resistor to 170 ohms.

The output load for the 6L6 is 2,500 ohms and the primary must carry at least 80mA. For the 6V6 the load must be 5,000 ohms and the primary must carry 60mA. With a tapped output transformer, the ratio can be adjusted to match the speaker used. The 6V6 will require correction in the output, which is done by a 7kΩ resistor in series with a mica 0.05μF condenser connected across the primary of the output transformer.

The circuit variations show other input methods and the alternative of inverse feedback for the 6L6. This is recommended for better quality of tone. All input circuits should be fully screened and the best quality components should be fitted if results are to be as good as possible. The circuit is designed to give a sharp cut-off in the lower frequencies, and "motorboating" will not occur if the values given are used.

A plucked guitar string does not produce the higher harmonics in much strength therefore it is not thought necessary to add further tone correction in this design.

As a guide to sizes, the chassis could be about 9in x 6in x 2in, and with all-metal type valves (GT) the height would be 5in.



Technical Forum

A.F. Amplifier Adjustment

We feel that many readers will agree that the construction of audio amplifiers has a particular appeal which is lacking in some other pieces of electronic equipment. In attempting to analyse this point we came to the conclusion that one of the main attractions of the audio amplifier is that, generally speaking, good results can be achieved without the constructor having to adhere to a published tried and tested circuit.

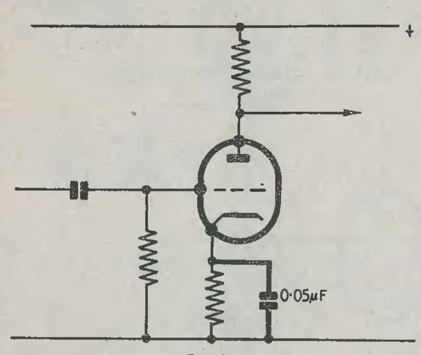


Fig.1
Partial bypassing of the cathode resistor to provide top lift

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He can, for example, extract parts of published circuits which have appeal in his particular case and with a little original design work combine them into a complete amplifier which has a degree of originality. Often one of the main attractions of this system is that it enables the optimum use to be made of components which are on hand. This is always an important point, particularly when it comes to applying some of the more expensive components such as valves and transformers.

There is, perhaps, one slight disadvantage in this mode of construction in that first-class results are not guaranteed to quite the same extent as they would be if a published circuit had been followed in detail. Sometimes the performance of the finished amplifier falls a little short of expectations, but it is usually possible to put the finishing touches to the circuit with one or two carefully chosen modifications. It is the purpose of this article to help in putting the finishing touches to an amplifier. As we are not considering any particular circuit, a number of different methods of achieving the same results will be given and the final choice left to the experimenter.

High Frequency Boost

We will deal first with the overall frequency response of the amplifier, as this is easily checked by either the use of an audio generator or one of the sliding tone gramophone records which are now available. Suppose this test shows that the response is falling off above 10,000 cycles; it is possible to obtain top boost by including inductance in the anode circuit of one or more of the valves, but this can so easily produce ringing—which is more objectionable than the fault which we are attempting to cure. A better solution is to use capacitative methods of boosting the top response, and these normally function by reducing the gain at the lower frequencies by negative feedback and arranging for the feedback to decrease as the frequency increases. The simplest method of achieving this is to employ partial decoupling of the cathode bias resistance in the first or second stage of the amplifier, as in Fig. 1. The complete removal of the cathode bypass capacitor will result in part of the signal voltage appearing at the cathode of the valve, and this will in effect be out of phase with the

signal on the control grid so that the stage gain will be reduced. Alternatively, the use of a large value capacitance will hold the cathode potential constant, and the full stage gain will be realised. Partial decoupling consists of employing a fairly low value capacitor which has a high reactance at low frequencies and therefore negligible bypassing effect. As, however, the frequency is increased so will be the bypassing effect, thus tending to increase the stage gain at the higher audible frequencies. The use of a 0.05µF capacitor in the cathode circuit gives a boost of about 2dB at 10,000 cycles and 4dB at 20,000 cycles. If the amplifier has two or more valves before the output stage it may be advisable to apply this method of cathode compensation to the second stage, as a partially decoupled cathode resistor in the first stage may increase the hum level.

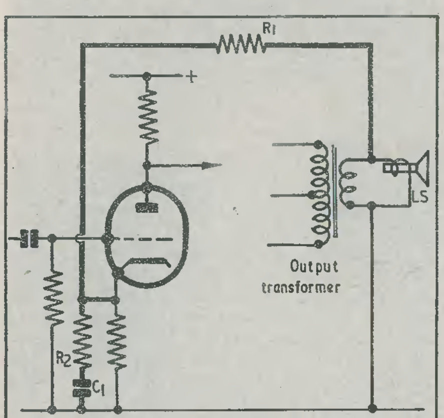

Fig.2
Top lift by means of a negative feedback loop
Typical values are C_1=0·01µF R_2=1kΩ R_1 dependent upon gain

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Some small loss in the top response of an amplifier may occur if it is necessary to use rather a lot of screened cable for signal carrying leads, and another method of achieving some high frequency boost is shown in Fig. 2. With this arrangement negative feedback is taken from the secondary of the loudspeaker transformer back to the cathode of the penultimate stage which is partially decoupled by a series R-C combination. At low frequencies the full feedback voltage is applied to the cathode of the valve, but as the frequency rises the reactance of the condenser decreases so that the proportion of the feedback voltage which appears at the cathode is reduced. It will be appreciated that R_1 forms the upper limb of a potential divider whilst R_2 and C_1 form the lower limb; so that, as the frequency increases and the reactance of C_1 reduces, the voltage fed back to the cathode of the valve will fall, thereby increasing its gain. In a typical condition the value of R_2 is made equal to the reactance of C_1 at about 15,000 cycles which will give a lift of some 6bB at this frequency.

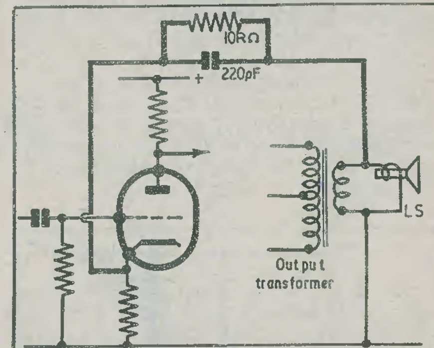

Fig.3
Top cut by means of a negative feedback loop

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High Frequency Attenuation

It may at first sight seem a little surprising that the need to attenuate the high frequency response of an amplifier should arise. Some form of top cut is often found in amplifier circuits, and may have been included to correct for a rising response due to a resonance in one of the transformers, or it may have been included to correct for a tendency towards instability at some frequency

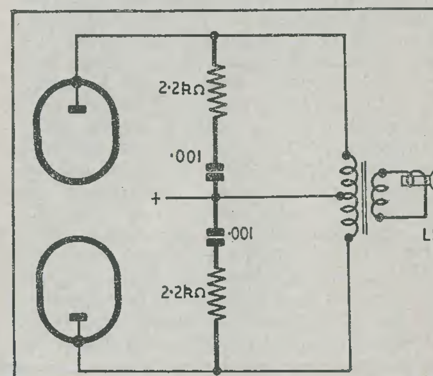

Fig.4
Phase correction by RC combination across output transformer

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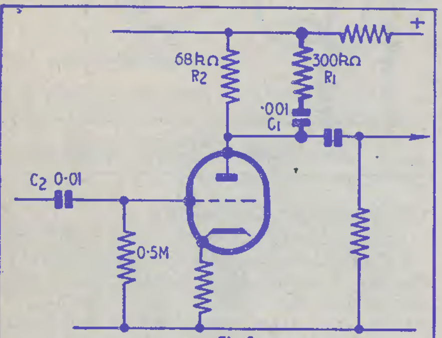
towards the top or perhaps above the audible range. A negative feedback circuit provides the simplest means of correcting for this type of defect, but in this case the feedback is arranged to reduce the gain of the amplifier above the required frequency (Fig. 3). Using the component values shown in the circuit diagram will give an attenuation of about 1dB at 20,000 cycles. It is usually around or above this frequency where a tendency to instability or parasitic oscillation occurs, and this small amount of negative feedback is usually sufficient to form a complete cure. It must be remembered that in all circuits in which the feedback is taken from the secondary of the speaker transformer care is required to ensure that the phase of the feedback is negative. It may be necessary to interchange the leads to either the primary or secondary of the output transformer to achieve correct phasing.



E695 Fig.5 A method of obtaining bass boost

Should the amplifier have an appreciable amount of negative feedback taken from the output transformer to a preceding stage, there may be a tendency to oscillation at a near-ultrasonic frequency due to phase shift within the feedback loop. It will be appreciated that excessive phase shift may produce a component of the feedback voltage which is actually positive and this can result in instability. Only in very severe cases will this result in the amplifier maintaining an oscillation; usually the effect is similar to ringing in the video of a television receiver. After a sharp transient a damped oscillation will be produced which will cause a blurring or reduction in the sharpness of transients. Phase shift can usually be neutralised by the addition of an R-C combination across the primary of the speaker transformer. Fig. 4 shows the position of these components, and the values recommended are typical in presenting an impedance approximately equal to double that of each optimum valve load at a frequency of 20,000 cycles.

Bass Boost

A simple but highly effective method of boosting the low frequency response of an amplifier is achieved by shunting the anode load of one of the voltage amplifier valves by means of a series R-C combination. The combination of resistor values shown in the circuit diagram (Fig. 5) is chosen such that the reactance of C_1 equals the resistance of R_1 at approximately 500 cycles. This will give a lift of about 5dB at 30 cycles. The anode load of the first valve is made up by the combination R_1, R_2 and C_1, but as the reactance of C_1 increases at the lower audible frequencies the effective anode load is increased and with it the stage gain. If less boost is required, the value of C_1 may be reduced.

Bass Attenuation

The value of the signal feed capacitors are chosen such as to give negligible attenuation at frequencies down to the lowest which it is required to reproduce. A very simple method of attenuating the bass response is to reduce the value of one or more of these capacitors (C_2, Fig. 5) so that as the frequency falls the capacity reactance increases, thereby reducing the signal voltage which is fed to the grid of the next valve. To give some idea of the effectiveness of this method of obtaining attenuation, should the amplifier be normally fitted with a $0.01\mu F$ capacitor for C_2, replacing it by a $0.001\mu F$ will reduce the bass response by 4dB at 30 cycles.

Attenuation of the lower frequencies can often be an advantage in reducing a speaker cabinet resonance, or perhaps in eliminating the effect of motor rumble on a gramophone player.

It is quite surprising how good an amplifier can be made by carefully experimenting along the lines suggested, whilst playing over one or two good records and carefully noting the effects of each step.

Amplified A.G.C. in Communications Receivers

continued from page 188

electrolytics for C_3 and C_4 and a 5,000 ohm ½ watt resistor for R_1. The voltage of the negative h.t. supply should not be allowed to exceed about 220 volts unless a separate heater supply is used for the a.g.c. amplifier, or the heater-to-cathode insulation of the latter may break down. The value of R_1 may be increased to reduce the voltage to the desired value, care being taken that the resistor is able to dissipate the heat evolved. The amateur constructor who incorporates a negative h.t. supply in his receiver will doubtless find other uses for it, for example in noise silencing circuits or other gain control devices.

A Transistor Pre-Amplifier for Luxembourg

By R. WALLACE

Introduction

DESPITE THE NEW TRANSMITTERS BROUGHT into operation at Radio Luxembourg in recent years to improve reception in the British Isles, many listeners still experience some trouble during the summer months, especially in the early part of the evening. This is often due to the poor signal-to-noise ratio of the "standard" 4-valve plus rectifier superhet in which the signal, as picked up by the aerial, goes directly to the frequency changer valve where it has to compete with all the noise generated by this stage. If signal strength is low, the wanted programme may well be comparable with, or even below this noise level, and consequently be lost altogether.

No amount of subsequent i.f. amplification will do anything to improve matters, and the only remedy is to employ a stage of r.f. amplification ahead of the frequency changer to raise the signal above the noise level existing there. In addition to providing the necessary amplification, the additional tuned circuit required for the r.f. stage also helps to reduce "image" or second channel interference which can be troublesome, even on 208 metres (1,439 kc/s), in the case of a receiver having a low intermediate frequency such as 110 kc/s. This trouble makes itself evident as a whistle which varies in pitch as the tuning control is "rocked" about the correct tuning position.

Where a receiver is not fitted with an r.f. stage the additional wavechange switching and the need to use a 3-gang tuning condenser, together with the careful layout and screening necessary to prevent instability, make converting a standard receiver a major operation even if there should be room for the additional components. In the case of a receiver employing bandpass tuning it might perhaps be simpler, as a triple gang tuning condenser would already be present, and even the matched bandpass coils themselves might be pressed into service as the aerial and h.f. coils so long as the bandpass effect had not been obtained by mutual inductance coupling. There still remains the extra valve to fit in, however, and on a crowded chassis this can be a bit of a headache.

Luckily there is an easy way out which gives all the advantages mentioned above without the need to make any major alterations to the receiver itself—namely an add-on pre-amplifier similar in principle to those commonly used to boost t.v. signals in "fringe" areas. As it is only required to operate on one specific channel, i.e. 208 metres, the tuning can be preset and the unit either removed or switched out of circuit when not required.

The exact form that the pre-amplifier shall take now remains to be decided. For convenience the unit should be physically small, both the gain and selectivity should be reasonably high, and the power supply should be self-contained if possible to avoid the need for any major modifications to the receiver with which it is to be used. In the writer's opinion the above requirements can best be met by a transistor circuit using positive feedback, or "reaction," to overcome the damping effect on the tuned circuit inherent with transistor operation.

The pre-amplifier described below is the outcome of much experiment and has proved to be very satisfactory. Through the use of a transistor the whole thing may be assembled on a small tagboard and, since instability presents no difficulties at the relatively low impedances at which transistors operate compared with similar valve circuits, the actual layout is not critical. No additional mains power unit or connections to the receiver power supplies are necessary since the only source of power needed is a 7½ or 9 volt battery which, at the very small current involved, should last almost as long as its normal shelf life.

The Circuit

The basic circuit of the pre-amplifier is shown in Fig. 1 and it will be seen that an r.f. transistor is used in the earthed emitter mode with positive feedback from collector to base via C_3, the necessary phase reversal occurring between the windings on the tuning coil which is a Teletron type HAX. These are actually designed for crystal receivers and all three windings share a common chassis connection at tag 1. The same firm do make a special transistor coil in which each of the windings is brought out to a separate pair of tags; however, the common chassis connection is no disadvantage in this particular instance; in fact, it reduces the possibility of wiring errors and simplifies construction somewhat, so the extra cost of the special coil is not justified.

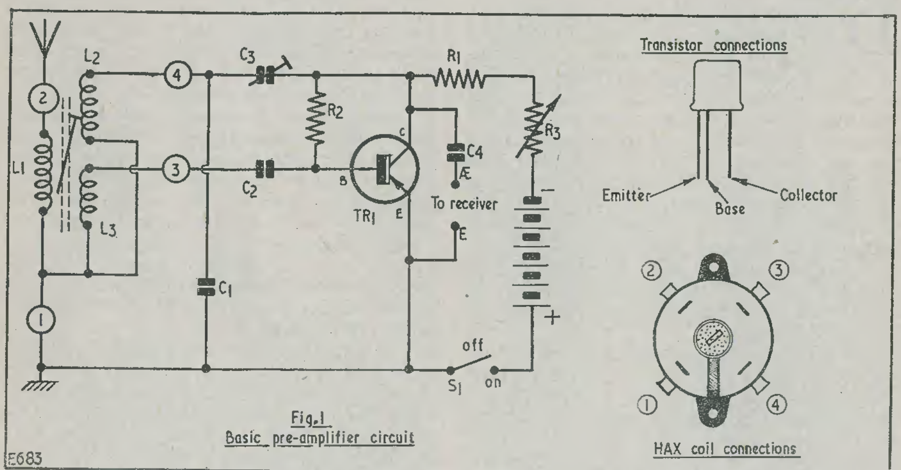


Fig. 1
Basic pre-amplifier circuit

Only one tuned circuit L_2, C_1 is used, and this is tightly coupled to L_3 which is in turn coupled to the base of TR_1 via C_2. This capacitor is made much smaller than is usual in transistor practice in order to keep the coupling loose and thus avoid damping the tuned circuit too heavily. Any loss of gain is made up by reaction, and this results in a much higher selectivity which helps to sort out the wanted station from its unwanted neighbours. There is no necessity for a tuned circuit in the collector circuit of TR_1 as in a conventional r.f. amplifier, as positive feedback via C_3 locks the whole circuit to any frequency to which L_2, C_1 is tuned. When in use the unit is, of course, also coupled to the input circuit of the receiver which is resonating at the same frequency.

Bias current for the transistor is provided by R_2 between the base and the lower end of R_1. Taking it from this point instead of directly from the negative power supply results in a certain amount of d.c. stabilisation being achieved, since any increase in collector current causes a larger voltage drop down R_1, which reduces the bias current and tends to offset the original collector current rise. This is not sufficient to prevent a slight increase in gain taking place as the transistor warms up, but this is not serious, and, so long as alignment is not attempted until the unit has been in operation for long enough to allow the transistor to reach its normal working temperature, no trouble will be experienced. R_3 is a gain control and acts by varying the collector voltage.

The output from the pre-amplifier is taken from the collector of TR_1 via C_4. The value shown is 50pF, and this should be satisfactory when used with most receivers. If reaction is difficult to obtain it may have to be reduced, but this is unlikely unless the receiver input impedance is very low. The length of the aerial used with the pre-amplifier will also affect reaction, and when this is very long it may be necessary to insert a capacitor of from 50 to 250 pF between the aerial and tag 2 of the coil.

When setting up the unit, tuning is carried out by adjusting the dust core inside the coil L_2, L_3. Normally this core is intended to lie under both L_2, L_3 and the aerial coupling winding L_1; however, with this arrangement a long aerial can damp the tuned circuit so heavily that it becomes impossible to obtain sufficient reaction, so the amount of coupling has to be reduced. This is achieved by inserting the core from the bottom end of the coil former instead of from the top so

that it lies under the larger coil L_2, L_3 only, and a hole must therefore be made in the chassis to allow for this.

Construction

The actual method of construction is left to the reader to decide for himself. As previously mentioned, there is no need to adhere strictly to any particular layout in view of the low impedances involved; nor is it necessary to screen the coil, since only one is used. Construction thus becomes extremely simple and the unit can be assembled on any odd tagboard, or, if a neater job is required, one of the many plastic cases which are available to house transistor and crystal receivers could probably be pressed into service as a suitable cabinet.

Of course all the usual precautions associated with transistor techniques should be observed. Always use a heat shunt of some kind, such as a pair of pliers, to grip the transistor lead-out wires when soldering, and make the actual joint quickly to avoid any overheating which, if it does not actually ruin the transistor, can completely alter its characteristics. The economically minded may prefer to use a transistor holder since this not only eliminates any overheating problems, but also enables the transistor to be taken out and used in other equipment when the pre-amplifier is not in use! Care should also be taken never to reverse the battery connections, although in this particular instance the high value of collector load resistance used should prevent any damage due to high forward currents. When fitting C_3, if the adjusting screw is in contact with either of the condenser "plates," make sure that this side is connected to TR_1 collector and not to the hot end of L_2. If this is not done, trouble may be experienced from capacity effects when a screwdriver is used to adjust reaction.

The gain control R_3, which should have a "linear law" track for smooth control of reaction, may in the case of Fig. 1 be combined with the on/off switch S_1, but if any difficulty is found in obtaining a linear control combined with a switch the version shown in Fig. 2 is recommended. Here a simple 50kΩ linear potentiometer is used in conjunction with a separate switch to switch the unit off when not in use. By using a 3-pole 2-way rotary switch the aerial may also be switched directly to the output terminals in the "off" position thus obviating the need to disconnect the pre-amplifier when other programmes are required. When fitting R_3 make sure that the correct pair of terminals is used so that the amount of resistance in circuit decreases as the control is turned clockwise; that is, the centre and right-hand tags as viewed from the rear of the control.

Alignment

Alignment of the pre-amplifier should be carried out when Radio Luxembourg is difficult to receive. In the morning when programmes in Dutch are transmitted is ideal as signal strength is then low, but usually remains constant without the fading which often occurs in the evenings. Before connecting the completed pre-amplifier to a battery carefully check the wiring for mistakes and ensure that the transistor is fitted correctly in its holder if one has been used; the collector lead-out wire of the yellow-red transistor being the one which is spaced away from the base and emitter leads which are close together with the emitter connection outermost. Thin sleeving may be used over these wires if they are left long.

If all is in order plug the aerial, and earth if used, into the pre-amplifier input sockets and connect the two output leads to the receiver; the "hot" lead from TR_1 collector going of course to the aerial socket and the "chassis" connection to the receiver earth terminal. If the receiver is of the a.c./d.c. type no connection must on any account be made directly to the receiver chassis. Should an earth socket not be provided, a connection may be brought out via a reliable 0.01μF paper capacitor rated at 1,000 volts d.c. "working" and the connection made to this. The aerial socket will of course already be isolated. It is advisable with all a.c./d.c. receivers to see that the mains plug is fitted the correct way round so that the actual chassis is connected to the neutral side of the supply; and this is easily checked with one of the pocket neon testers sold for such purposes. The tester should be held against the chassis with the receiver switched on and if the neon glows the mains connections must be reversed.

Having made sure that all is in order and having connected the unit to the receiver, remove the dust core from the coil, set C_4 to minimum capacity, i.e. fully unscrewed, and turn R_3 forward for approximately two-thirds of its travel so that about one-third of the resistance is in circuit. Aligning the unit with this control set to a position below maximum gain will enable compensation to be made for any reduction of battery voltage with age whilst still allowing the gain to be reduced by inserting more resistance when conditions improve, or as the transistor warms up. As an added precaution a milliameter may be inserted in one of the battery leads before switching on for the first time. If all is well the current should be in the neighbourhood of 100 to 150 microamps, depending on the voltage applied.

With both the pre-amplifier and the main receiver switched on allow a quarter of an hour or twenty minutes for the working temperature to be reached, after which time alignment of the unit may be commenced. To do this switch the pre-amplifier off temporarily and tune the main receiver to Radio Luxembourg in the usual way. If the pre-amplifier is the Fig. 1 version, the aerial must be unplugged from this and plugged into the receiver aerial socket, but if it is the Fig. 2 type it will only be necessary to switch off the pre-amplifier; aerial change-over occurring automatically.

Leaving the core in this position the reaction control C_3 is next adjusted with a screwdriver to increase the gain and sharpen up the tuning. As the value of C_3 is increased the tuning core will need to be unscrewed slightly to compensate for the additional capacity, and the two controls are best adjusted together, increasing C_3 and "rocking" the tuning core about the correct position, until oscillation just starts to set in and the programme disappears. The gain control

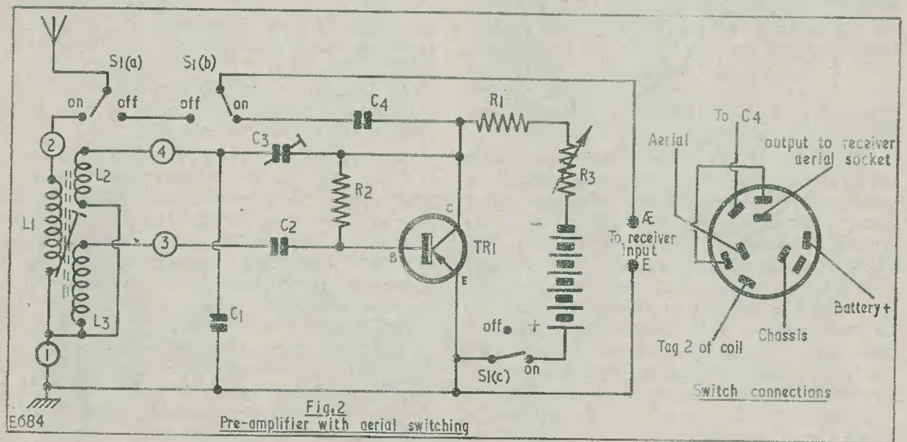


Fig. 2
Pre-amplifier with aerial switching

COMPONENTS LIST

R_1	22kΩ
R_2	470kΩ
R_3	50kΩ linear potentiometer with s.p. switch (less switch for Fig. 2)
C_1, C_4	50pF silver mica or ceramic
C_2	150pF silver mica or ceramic
C_3	50pF "postage stamp" trimmer
S_1 (a) (b) (c)	3-pole, 2-way, rotary switch (Fig. 2 version only)
$L_1/_2/_3$	Teletron type HAX crystal set coil
TR_1	Yellow-red r.f. transistor or equivalent

Battery, 7½ or 9 volts
Twin socket strip for aerial and earth connections
Pair of red and black wander plugs for output leads
Chassis, case, if used

Having tuned-in the station accurately on the main receiver, return the aerial to the pre-amplifier input and switch on again. It is important that the receiver tuning control is not touched once set, but the volume control will probably need to be turned down as the pre-amplifier tuning is brought into line. Next insert the iron dust core into the HAX coil from the bottom end of the coil former and screw inwards with a non-metallic trimming tool, or an old knitting needle filed to the shape of a screwdriver blade. As the core is screwed in volume will increase and any receiver noise and heterodyne whistles will decrease. Without reaction, tuning will be very broad; but it should be possible to find a point where volume is maximum.

R_3 should then be backed off slightly until the programme reappears, and the tuning core setting given a final touch.

If the alignment has been carried out correctly and the unit is tuned exactly to the carrier frequency, the quality of the reproduction will be somewhat "bassy" due to sideband cutting, but if R_3 is backed off still further the bandwidth will increase and the higher frequencies of the modulation will become more evident. So also will any sideband splatter from adjacent stations, and the setting of R_3 chosen in use will depend on conditions. For maximum selectivity and gain the control must be turned clockwise towards the point where oscillation occurs, but as conditions improve it may be backed off a little to improve the quality. The unit should never be allowed to remain in an oscillating condition for any length of time as radiation can occur which may cause interference on neighbouring receivers which are tuned to the same frequency.

Conclusion

Finally, as well as improving the signal-to-noise ratio under bad reception conditions and reducing second channel interference, the use of this simple gadget should also help to counteract the effects of fading by bringing signal strength up to a level where the main receiver a.g.c. system can become operative. This will result in a more constant programme level where, without the additional amplification, signal strength is insufficient to overcome the delay voltage at the a.g.c. diode.

RADIO MISCELLANY

continued from page 190

and some of the little they nominally retain is "shared" (when they lose priority), or worse still, blatantly stolen. The propaganda broadcast stations are the chief offenders in the latter respect. They are not only an unnecessary evil, but a double evil. Each is marked by a jamming station to worsen the congestion. Quite frequently, too, a counter-propaganda broadcaster of greater power swells the pandemonium.

No one could fairly deny the validity of the amateurs' claim. They have a right by tradition, it gives opportunity for private experiment, it contributes to international friendship, provides a ready-made network of communication in times of emergency and serves as a training ground for young technicians. Yet to my mind there is a still more important reason. Amateur radio is one of the remaining bastions of the freedom of the individual. We live under the shadow of far too many "Thou shalt nots". In a world where rules have become far more important than the person, where the private citizen is treated more like an ant on an ant-hill, and the democracies grow more totalitarian every year, our few precious remaining liberties must be vigorously defended.

At the conference the voice of world amateurs will be heard although the weight and influence carried may be small. Let us hope that a sense of fair play may prevail and that the slender amateur allocations will not be further plundered merely because they are the most defenceless of the groups concerned.

Multi-Purpose

Judging by the complete absence of response on the subject of "reviving" valve-type prefixes and numbers which have worn off the glass, there just isn't any method. One can either re-etch the number before it disappears or, once having lost it, carry out a series of tests to establish it as an exact equivalent.

Last month a reader was good enough to let us have some details regarding etchants and now L.E.H. (Erdington, B'ham) sends a cutting from the *B. J. Almanac* of a method for name etching on glass bottles used for storing photographic chemicals. Experienced readers will already know that labels on such bottles either immediately peel off or else the markings fade away like disappearing ink.

The glass surface is warmed and a small area is thinly coated with melted candle wax. When cool the required lettering is scratched into the wax to expose the glass. A shallow bath, made preferably from folded sheet lead is prepared, into which a little calcium fluoride is placed. This is moistened with pure sulphuric acid and slightly warmed—only a sufficient quantity to submerge the small part of the surface to be treated when laid flat into it need be made up. Ten minutes is suggested for the acid to eat its way sufficiently deeply.

L.E.H.'s chief interest is test gear, and he mentions a number of items he has successfully made up. He asks about some of the less obvious uses to which test gear can be put. No doubt readers have found unusual applications for the many items of test equipment they themselves have built. If so, why not send a short description to the Editor?

ARMSTRONG WIRELESS & TELEVISION CO LTD

We regret that in some copies of the September issue, the telephone number in this company's advertisement on page 138 was incorrectly given as NORth 321—this should have read NORth 3213. We tender our apologies for this omission and for any inconvenience caused to our readers as a result.

A Constructor Visits the 1959 National Radio Show

THE 26TH NATIONAL RADIO SHOW WAS AGAIN held in the familiar surroundings of Earls Court, where it has been held since 1926 with the exception of the war years. The attendance this year was approximately 310,000 compared with 330,000 last year.

With very nearly 10 million television licences now issued in this country the accent on t.v. at the Radio Show is not at all surprising, and most manufacturers were showing their latest "Slim Line" 17in and 21in televisors incorporating the new 110 degree wide-angle cathode ray tubes. Several now use plug-in printed circuits to make servicing simpler, cheaper and more rapid. The portable t.v. receiver was also very much in evidence, and the use of the new tubes and latest techniques has resulted in a considerable reduction in size and weight. One portable 17in televisor is only 12¾in deep and weighs but 31½ lb.

Most of the radio manufacturers were showing at least one transistor radio set in addition to the traditional ranges of receivers using valves. Considerable technical advances have been made in the transistor radio field, designed at producing better quality and sensitivity. One firm which specialises in this type of set has used the latest transistors to extend operation to the short wave band. The addition of an extra stage to their receivers has allowed an increase in the use of negative feedback, giving improved quality, and has given a reserve of sensitivity for low signal areas. Prices of all radio sets show a slight reduction compared with last year.

Tape recorders were very much in evidence, and manufacturers are trying to increase the popularity of their products by introducing new lines of small, good quality recorders at attractive prices. There are now several excellent machines retailing at prices below £30. Efforts are being made to simplify the operation of these recorders, and one company was exhibiting a low-priced model incorporating the new Garrard magazine-loaded deck. This deck requires no threading operations whatsoever as the magazines used need only to be dropped into position on the deck to be used for record or playback. A single speed of 3¾in per second is used with twin track, giving a total playing time of 1 hr. 10 mins. Frequency response is quite good, extending at present to 8 kc/s. The Garrard representative stated that it is hoped to market this deck early in the New Year at a price well below £20.

In the higher price range many tape recorders had greatly improved facilities for serious use, including mixing, superimposing and improved monitoring methods. The Veritone stand was giving live stereo recording demonstrations on their new twin track machine. This is virtually two recorders in one and has two separate record amplifiers and two playback circuits giving extreme flexibility in use. Independent volume controls are provided for both record and playback balance, and independent bass and treble controls are incorporated in the playback amplifiers to allow compensation for different loudspeaker characteristics. The complete recorder can be used for twin track monaural work, with combination of the tracks if desired, or for stereo. The live recordings of the Parker Royal Five were most excellent and this was one of the most novel and interesting demonstrations at the Show. Several tape deck manufacturers were exhibiting decks which could easily be converted for stereo or twin track monaural use by the fitting of extra heads, an attractive proposition for the home constructor wishing to assemble a stereo tape recorder by easy stages. A new line is a tape-playing unit designed to plug into the pick-up sockets of a normal radio set.

Many radiograms and portable gramophones for the reproduction of stereo records were on show in addition to the usual single channel models.

For the second time the National Radio Show had a complete section of soundproofed rooms devoted entirely to Hi-Fi demonstrations by amplifier, loudspeaker, gramophone and tape recorder manufacturers. Most were concentrating on stereo demonstrations, although the usual "spectacular" effects were noticeable by their absence. The accent was on good high quality stereo equipment for the home; as one firm put it, "Stereo has now been established long enough to do without party tricks". The G.E.C. gave a very fine demonstration of two new loudspeaker systems for the home constructor using Metal Cone speakers and presence units for full range high quality response. Their new slim Periphonic system using two Metal Cone loudspeakers and two High Flux presence units has a smooth response down to 35 c/s. Use of the Periphonic principle with the two bass speakers connected in push-pull results in cancellation of even harmonic distortion produced by the speakers and gives a very faithful reproduction of bass. Also demonstrated was a system small enough to be placed on a bookshelf but having an amazingly wide frequency range. Details were given for conversion of the octagonal periphonic system by the addition of the new High Flux presence unit and Power Brackets for improved low frequency response. W.B. demonstrated a range of conventional loudspeaker systems for single channel and stereo use and were also featuring their column assemblies designed to give high fidelity while occupying the minimum of floor space. Another solution of the space problem in stereo systems was given by Goodmans with their box form assembly. A very large number of amplifiers and pre-amplifiers for stereo and monaural use were on show. Most pre-amplifiers now have sufficient gain to work successfully with the low output magnetic stereo pick-up heads or from a tape recorder playback head. Prices of complete stereo amplifying systems have been considerably reduced and range from well below £10 upwards. Tripletone were showing a novel single-channel amplifier for approximately £7. Two of these units may be bolted together to form a stereo pair with only one set of controls. G.E.C. exhibited a single-channel 12-watt amplifier with separate pre-amplifier and a combining unit by means of which two of these may be coupled for stereo.

Kits and components for the home constructor were on show, but since this is primarily a commercial event there was not so much in this line as, for instance, at the Radio Hobbies Exhibition. The Bulgin stand had a remarkable display of that firm's range of indicator lamps and micro-switches. A new Bulgin product of particular interest to the constructor is their screened jack plug for co-axial or twin-screened cable. The T.C.C. stand showed a new range of electrolytic capacitors with tantalum anodes. This type of capacitor has much lower leakage than the conventional aluminium electrolytic and a much wider temperature range. Also exhibited was a display of T.C.C. printed circuits, including one for the Mullard 510 amplifier and a new development, the "flush bonded" printed circuit in which the copper is bonded flush into the surrounding insulating board after etching. This type of circuit has applications in special switches for computers.

Labgear Limited introduced a new range of aerials for "difficult" areas including an 11-element beam for Band III. This is for use in sites where ghosting is bad. Other types featured improved matching methods, an extension of the Labgear "In-Line" range of composite arrays providing individual orientation of the Band I and Band III arrays, and a special three-band model for reception of a Band III signal from one station and a Band I and Band III signal from another station. Labgear also showed their range of aerial accessories including a new low-loss diplexer for channels 9 and 11. Several manufacturers showed their latest designs in loft and room aerials.

Once again the non-commercial stands were of interest to the technically minded and to the public in general. The "Careers in Electronics" stand advised visitors on possible careers in the industry and gave information on the necessary qualifications and technical college courses. On the stand was a reproduction of a typical modern television servicing workshop in which technicians were repairing customers' sets. Realistically, not all the sets being serviced were this year's models. The Royal Navy showed shipborne communications equipment, a teleprinter installation and radar apparatus. Of interest to the younger generation was a model train layout powered by hand generators (this was great fun for competitive racing!) and an attack simulator to test accuracy in firing at a moving target. The R.A.F. stand was also designed for audience participation and visitors were invited to try their skill at guided missile firing, aircraft recognition and fighter control. Also on the stand were a Vampire jet fighter, and an airfield control radar installation, and R.A.F. guided missiles.

Finally, any review of the 1959 National Radio Show would be incomplete without a mention of an exhibit on the Mullard stand —the Meeble bird, a bird looking like an outsize escapee from a Guinness advertisement. This remarkable animal was unfailingly able to answer questions from its library of cards when asked by pushing a button. All with no visible means of connection to the buttons. Unfortunately, I was unable to find a suitable button so that I could not ask it where I had parked my car.

C.M.P.

Plessey "Hyperlytic" Capacitors

Long shelf life and a working life of the order of ten years are achieved in new type electrolytic capacitors developed by The Plessey Company Limited, Kembrey Street, Swindon, Wiltshire. These capacitors are known as "Hyperlytic" and they are available in many capacities between 0.5 and 12,000μF.

An exacting specification calls for the use of a high purity etched foil anode material. This, together with certain unique manufacturing techniques, provides a stable capacitor having low leakage and high insulation resistance.

Two types are available, the 1,000 and 11,000 series. The 1,000 series has a temperature range of −30 deg. C. to +85 deg. C. and very low leakage currents of under .01CV microamps, except where the CV is less than 500 when leakage current can be 5 microamps. The 11,000 series on the other hand has a working temperature range of −20 deg. C. to +50 deg. C. with a somewhat higher leakage current.

The standard capacitance tolerance is −20 +50 per cent, but closer limits can be worked to on request.

Where required, capacitors can be wound in such a way that self-inductance is reduced to a minimum so as to enhance performance at the higher audio frequencies.

RADIO

AUTOMATIC FREQUENCY CONTROL for FM TUNERS

by R. TAYLOR

THERE ARE SEVERAL RELATIVELY INexpensive f.m. tuner designs available at the moment which are capable of excellent results. Unfortunately, some have a tendency to varying degrees of oscillator drift, which necessitates constant adjustment of the main tuning capacitor during the warming-up period. It is generally conceded that oscillator drift is the major problem in the design of f.m. tuners, and it is not unusual for drift to occur for a period of thirty minutes, or more, causing continual annoyance to the user.

The use of crystal control of the oscillator, one crystal for each programme, is probably the ideal solution to this problem, but three crystals are not only expensive, but are useless should the user move away to a transmitter area using different frequencies.

Another method of reducing drift is by the use of automatic frequency control (a.f.c.). Although not so efficient as crystal control, because no system of a.f.c. can generate and then apply a correction voltage until a drift has occurred, it can reduce it to negligible proportions. There are a number of ways of arranging a.f.c., but probably the most popular method is the use of a reactance valve, which derives the necessary error voltage from the discriminator. This can reduce drift by a ratio of some 8 to 1, and has the advantage of being considerably cheaper, and easier to apply, than crystal control.

A famous printed circuit f.m. tuner kit, which when built drifted badly, has been completely cured of this fault by the a.f.c. about to be described, and the connections in the circuit diagram apply to this tuner. As the principle can be applied to almost any tuner, it should be easy to adapt this design to suit individual circumstances. As an example, a suggested circuit is given for the Jason tuner (*Radio Reprint No.* 2 and *Data Book* 12, Data Publications).

Construction

Fig. 1 shows the basic circuit and necessary connections to the printed circuit kit. Fig. 2 shows how the reactance valve should be connected to the Jason tuner.

The first essential is to arrange that the reactance valve base is as close to the oscillator stage of the tuner as is possible. In the set modified by the writer, this necessitated a hole being punched in the side of the chassis to accommodate the B9A valve socket, but in other designs of f.m. tuners it may be easier, and more convenient, to mount the valve socket on top of the chassis. It is important to keep the connections of C_1 between the anode of the reactance valve and oscillator coil short, but the disposition of the other components is of less importance. It is advisable to use a screened connection between the discriminator and R_4.

RADIO HOBBIES EXHIBITION, 1959

The Radio Hobbies Exhibition is again being held this year at the Royal Horticultural Old Hall, Vincent Square, Westminster, London S.W.1, from the 25th to the 28th November inclusive. We recommend this exhibition to those readers who have not previously attended, and will be pleased to meet visitors at Stand 24.

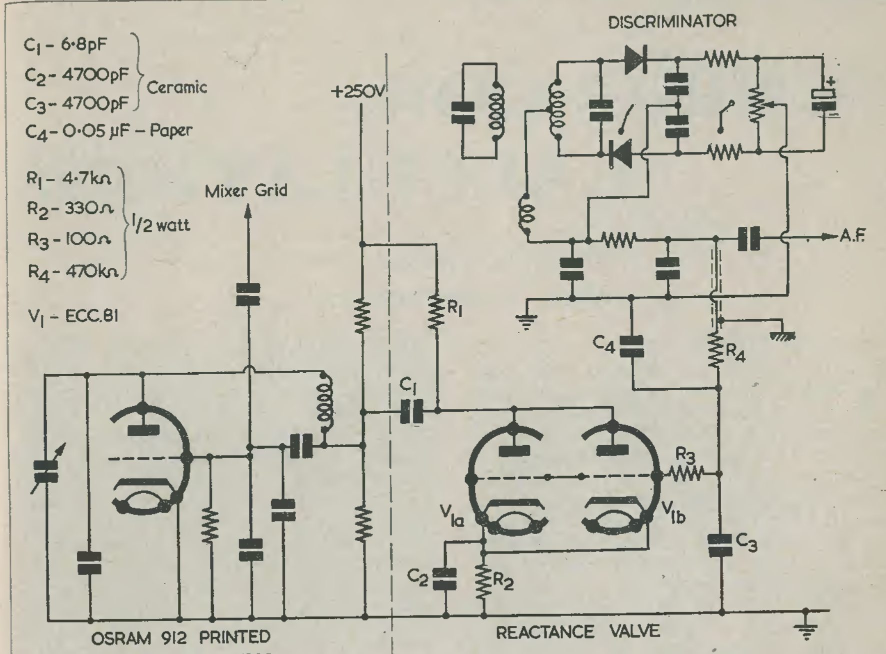


FIG.1.

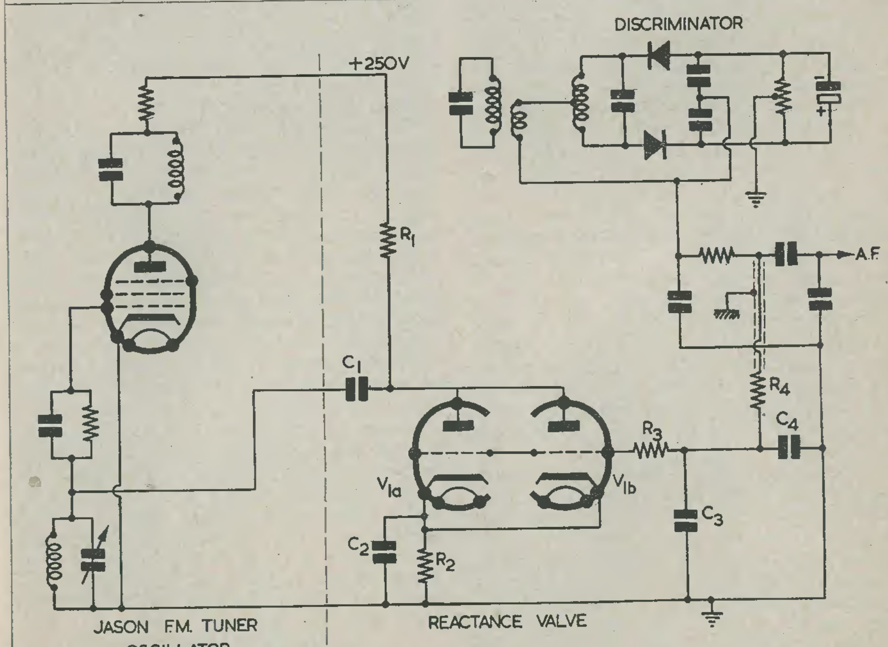


FIG.2

TUNING COIL CALCULATIONS

Some one-armed combat

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

Sizing-up the Problem

Anyone who has looked into the considerable amount of literature that has been written on calculating the inductance and number of turns required for a coil to tune over a specified range of frequencies will not need to be reminded that the process, to say the least of it, is rather involved. The fact that eminent mathematicians throughout the world have devoted themselves to a great deal of research into the properties of the humble coil of wire clearly indicates that simple formulae or "rules-of-thumb" are hard to come by. When one ponders over the graphs and charts that abound in wide variety, and the quite large number of formulae which have come to be known as so-and-so's "method" after those who derived them, it is small wonder that the likes of us can find the subject a trifle puzzling.

The trouble usually starts when one gets the urge to design and make tuning coils at home. It all looks so tantalisingly easy; consult a chart, or work out a formula, and the job's done. Or so we think, until we see there's a different formula on the next page, so we try that one and find the answers don't agree. Fearing the worst, we work it all out again and arrive at something totally different that doesn't bear the slightest resemblance to the previous figures. Further cogitation invariably befuddles a confused mind, so we throw it all away and start again, and eventually repair to the workshop to wind THE COIL—only to find that it tunes anywhere but where we want it to when we try it out.

Having gone out and bought one we are completely amazed that Mr. Wearite, Mr. Denco, Mr. Osmor, and many others of that ilk seem to find the answer that so skilfully eludes us, and produce coils that work. Being somewhat imbued with the idea that as amateurs we ought to be able to roll our own, there seems to be some justification in probing the problem, if only to get some fun and experience out of it.

The fly in this particular brand of ointment gets in at the design stage—on the ground floor, so to speak. He attacks like a cunning enemy before we are fully wide awake, confuses us because we are not fully prepared, and puts us to flight because we perhaps find it easier not to stop and grapple with him. His weapons are graphs, charts, formulae, mathematical expressions and what have you—all in diverse forms and complicated in varying degree. We don't always see where the attack is coming from, for there are so many variables to take into account. To put the matter in more practical form, we find that factors like coil shape, ratio of length to diameter, size of wire, number of turns, close-winding and spaced-winding all contribute to producing a solution that seldom can be relied upon to be correct on a first calculation, unless a fair amount of care is taken in our working.

Getting to Grips with It

We said earlier that several investigators had produced methods for designing tuning coils. Although some are very complicated, they are nevertheless accurate to a high degree provided we can manipulate the formulae, and this invariably requires a higher standard of mathematics than many of us possess. To help people like us whose algebraical appreciation and mathematical imagination is almost an unknown quantity, certain gentlemen have produced, from time to time, formulae that are somewhat simpler yet accurate enough for most practical purposes. In our combat with the mathematical monster, we thus have a few wrestling holds we can use to subdue the beast. A certain amount of effort is still required from us to secure victory, but the job is made a lot easier. One of the obliging gentlemen is one known as J. H. Reyner, some of whose benevolence is to be found in the *Wireless World* Diary. A nice, neat, little formula he's produced for us; one that a schoolboy can work out. He says that

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

where L = inductance in μH.
N = number of turns
D = outside diam. of coil in inches.
S = length of coil in inches.
d = depth of coil in inches (i.e. half the difference between inside and outside diameters).

It should be stated that the symbol S has been used here in preference to the lower case letter l to avoid confusing it with the figure 1.

This formula is for multi-layer coils. For single-layer coils we merely ignore the term within the brackets.

Ju-jitsu, or Tying Things Up

There was a time in the writer's more active youth when he made some practical enquiry into the gentle art of Judo. This continued up to the point where it began to hurt too much, but a certain amount of useful information was acquired in the process. For instance, to apply a leg lock and a strangle hold at the same time when the adversary was on the mat invariably brought matters to a swift conclusion, because pressure was applied in two places at once. We can do something similar here. By using one formula to augment another our problem can be simplified, especially after some jockeying for position and manhandling of the maths.

The usual procedure adopted to design the winding for a tuning coil is first to find the value of inductance which, with a known capacity swing, will cover a required range of frequencies, and from the inductance value so found the number of turns on the coil is calculated. This necessitates a certain amount of intelligent guesswork in allotting dimensions for the proposed coil in order to solve the equations. Some people call it Christian Science.

It was while a certain amount of finagling with formulae was being indulged in that the writer noticed a possibility of streamlining the working, or, to put it another way, of applying two holds at once to make submission come sooner. Let us therefore proceed to apply Judo to maths by easy stages and show how the trick is performed.

Hold No. 1—The Leg Lock

The basic formula connecting frequency, inductance and capacitance at resonance reads:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f = frequency in c/s.
π = 3.14
L = inductance in Henrys (H).
C = capacitance in Farads (F)

Sparring for an opening, we square both sides and get:

$$f^2 = \frac{1}{(2\pi)^2LC}$$

Throwing it on the mat and turning it round a bit so that:

$$L = \frac{1}{(2\pi)^2f^2C}$$

we are able to get more comfy, and make things easier by converting to μH, pF and Mc/s. The tighter grip becomes:

$$L = \frac{10^6}{(2\pi)^2f^2C}$$

Applying more pressure:

$$L = \frac{10^6}{6.28^2f^2C}$$

$$= \frac{25340}{f^2C}$$

And making the hold more secure:

$$\sqrt{L} = \frac{\sqrt{25340}}{f\sqrt{C}}$$

$$\text{or} \quad \sqrt{L} = \frac{159}{f\sqrt{C}} \quad \ldots \ldots \ldots (1)$$

We can now turn our attention to

Hold No. 2—Initial Struggling

We won't inflict too much pain to start with, so let's show our intentions by dealing with the single-layer coil. At this juncture, we can introduce Mr. Reyner's strategy:

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

Take the first grip by multiplying throughout by 5 to solve for N:

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

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

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

therefore

$$N = \frac{\sqrt{17.5}\sqrt{L}\sqrt{(D+2.28S)}}{D} \quad \ldots (2)$$

Having got it more or less where we want it by leaving the radicals in the manner shown, we can now effect the coup de maitre by using expession (1) to replace $\sqrt{L}$ in (2). In this way we can effect:

Hold No. 2—The Strangle

We can help ourselves here by first working out the value of $\sqrt{17.5}$, which comes out to 4.18. And now we can really get down to some serious business:

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

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

$$=\sqrt{\frac{665^2\left(1+2.28\frac{S}{D}\right)}{f^2CD}} \quad \ldots \quad \ldots \quad (3)$$

At this stage our adversary, the mathematical monster, should rightly bang twice on the mat and admit submission. Surveying the result of our energies, we observe with some delight that we have knocked L out of him. Notice, too, that the process has also been rather quick, and leaves us with a formula that looks fairly tidy. Also, it is not difficult to solve. By using log tables (not to be confused with home-made furniture) the elusive N=number of turns comes out very nicely, thank you. A simple example will show how easy it is.

Example 1

It is required to wind a coil $\frac{3}{4}$in long on a $1\frac{1}{2}$in diameter former, to tune to 7 Mc/s with 50pF. Applying formula (3) above:

$$N=\sqrt{\frac{665^2\left(1+2.28\left(\frac{0.75}{1.5}\right)\right)}{7^2\times 50\times 1.5}}$$

$$=\sqrt{\frac{665^2\times 2.14}{49\times 75}}$$

$$=16 \text{ turns (by logs).}$$

From wire tables we find that 16 turns in $\frac{3}{4}$in is just achieved by 19 s.w.g. E & SSC, close-wound. If we need to know the inductance of the winding, it can be derived by applying the expression previously worked out for L, thus:

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

$$=\frac{16^2\times 1.5^2}{17.5(1.5+1.71)}$$

$$=\frac{256\times 2.25}{17.5\times 3.21}$$

$$=10.25\mu H \text{ (by logs).}$$

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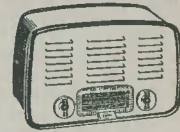

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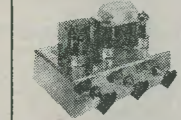

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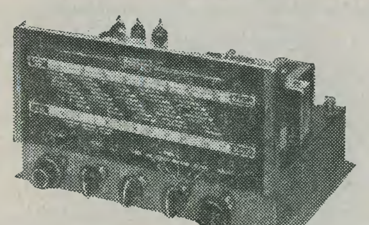

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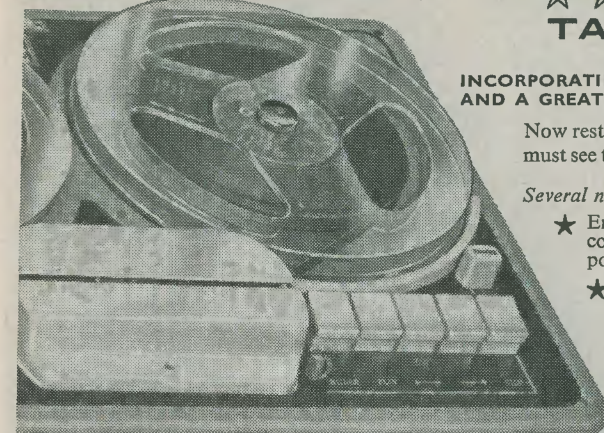

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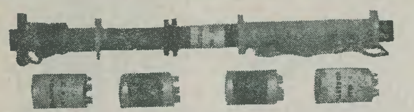

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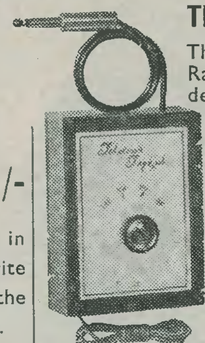

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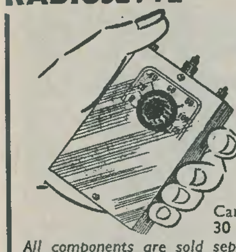

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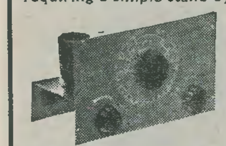

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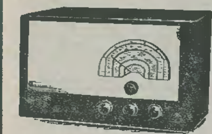

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1C5	10/–	7C6	7/6	DL94	7/6	PY81	8/6
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1R5	7/–	7Z4	7/–	EB91	5/–	VR105/30	6/–
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6A7	9/–	7475	6/–	VS110	6/–	UBC41	9/–
6A8GT	9/–	CV135	5/–	EF36	5/–	UBF89	9/–
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6AC7	5/–	CV138	5/–	EF40	11/6	UCH42	10/–
6AG5	5/–	CV140	5/–	EF42	11/–	UCL82	12/–
6AL5	5/–	723A/B	55/–	EF89	8/6	UF80	9/6
6AM6	5/–	2K25	65/–	EF91	5/–	UF85	9/6
6C4	5/–	D77	5/–	EF92	5/–	UF89	10/–
6D2	5/–	DAF91	7/–	EL42	10/–	UL41	8/–
6F12	5/–	DAF96	9/–	EM34	7/6	UL84	9/–
813	65/–	DCC90	9/–	EY51	10/–	UY41	7/6
GT1C	15/–	DF91	7/–	EY86	10/–	UY85	8/–
6LG6	8/–	DF96	9/–	EZ40	7/6	UY1N	18/7
6L6M	10/–	DH63	7/6	EZ80	7/–	VR53	5/–
6Q7G	7/6	DK91	7/–	EZ81	7/–	VR54	2/6
6SH7	5/–	DL91	7/–	KT33C	8/6	VR56	5/–
6SL7	6/–	DK96	9/–	MU14	7/6	VU39	7/6
6SN7	6/–	DL33	9/–	N14	10/–	Z77	5/–
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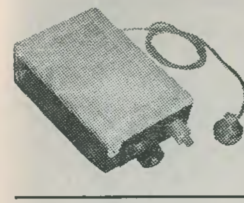

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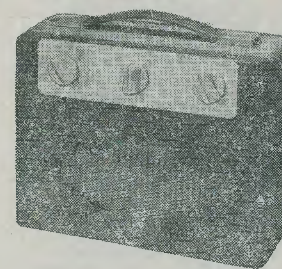

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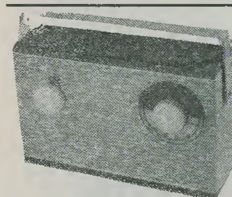

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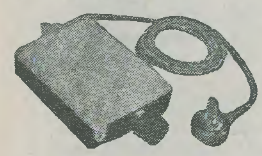

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continued on page 231

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1S5	6/6	6SH7M	5/–	ARP12	5/–	EZ81	8/–
1T4	5/–	6SJ7M	7/6	DC70	7/6	GT1C	7/6
2A3	8/6	6SK7M	6/6	DET24	12/6	GZ32	12/6
2X2	3/6	6SL7GT	7/–	DF73	7/6	HK24G	25/–
3A4	4/6	6SN7GT	4/6	DL70	7/6	KT33C	8/6
3A5	12/6	6SQ7M	7/6	EA50	1/6	OA2	10/–
3Q4	6/6	6ST7	8/6	EABC80	10/–	PCC84	8/6
3S4	8/6	6V6G	7/6	EAC91	4/6	PCC85	9/–
3V4	8/6	6X4	5/6	EAF42	9/–	PCF80	9/–
5R4GY	9/6	6X5GT	6/6	EB34	2/–	PCF82	9/–
5Y3GT	7/6	7B7	8/–	EB91	4/–	PCL82	11/6
6AC7M	5/–	7C5	8/–	EBC33	5/–	PL81	12/6
6AG5	3/6	7C6	8/–	EBC41	8/6	PL82	8/6
6AK5	5/–	7S7	9/6	EBF80	9/–	PL83	8/6
6AL5	4/–	7Y4	8/–	EBF89	9/6	PY80	7/6
6AM6	4/–	12A6M	6/6	EC80	12/6	PY81	8/6
6AQ5	8/6	12AT6	8/6	ECC82	8/6	PY82	8/–
6AT6	7/6	12AT7	8/6	ECC83	8/6	PY83	8/–
6AU6	7/6	12AU7	3/6	ECC84	9/6	TT11	4/–
6B8G	3/6	12AX7	8/6	ECC85	9/–	U25	12/6
6BA6	7/6	12AU6	9/–	ECF80	11/6	UAF42	9/–
6BE6	7/6	12BE6	8/6	ECF82	11/6	UBC41	9/6
6BH6	7/6	12C8M	7/6	ECH42	9/–	UBF89	9/6
6BJ6	7/6	12K7GT	6/6	ECH81	10/–	UCC85	9/6
6BR7	11/6	12K8M	12/6	ECL80	10/6	UCH42	9/–
6BW6	9/–	12Q7GT	6/6	ECL82	11/6	UCH81	9/6
6C4	4/–	12SC7M	2/6	EF36	4/–	UF41	9/–
6F32	6/6	12SJ7M	5/–	EF39	4/6	UF42	8/6
6F6M	5/6	12SK7M	5/–	EF41	9/6	UF89	9/–
6J5GT	4/6	12SQ7M	8/6	EF50	2/6	UL41	9/–
6J5M	5/–	35L6GT	9/6	EF50(S)	4/–	UL84	9/–
6J6	4/–	35Z5GT	8/6	EF80	7/6	UY41	8/–
6J7G	7/6	35Z4GT	7/6	EF85	9/6	UY85	8/6
6K7G	3/6	42	7/6	EF86	13/6	UABC80	
6K8G	6/–	50L6GT	9/6	EF89	9/–		10/6
6K8M	10/6	80	6/6	EF91	4/–	VLS631	12/6
6H6M	2/6	446A	10/6	EL32	4/–	VP23	5/–
6L6G	8/–	801A	7/6	EL41	9/6	VR150/30	
6L6M	10/6	803	20/–	EL84	9/–		7/6
6Q7G	7/6	830B	15/–	EM80	9/6	VS70	3/–
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continued from page 229

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