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Self-Calibrating Transistor Tester

VOLUME 11
NUMBER 10
MAY
1958

The RADIO Constructor

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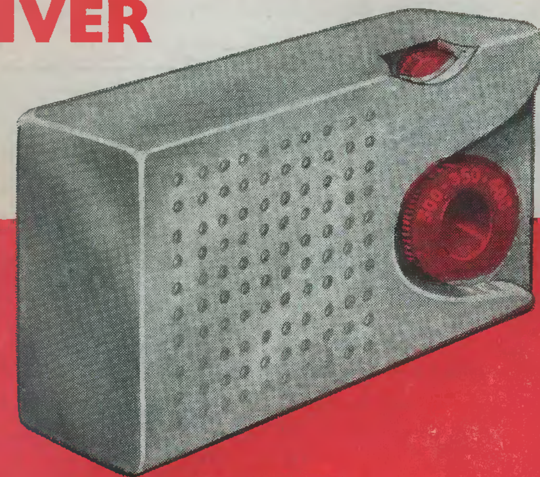
The Mini 7 SUPERHET POCKET TRANSISTOR RECEIVER



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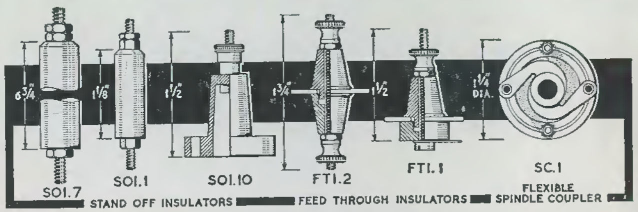

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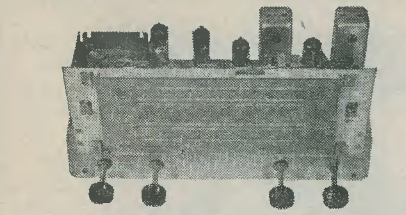

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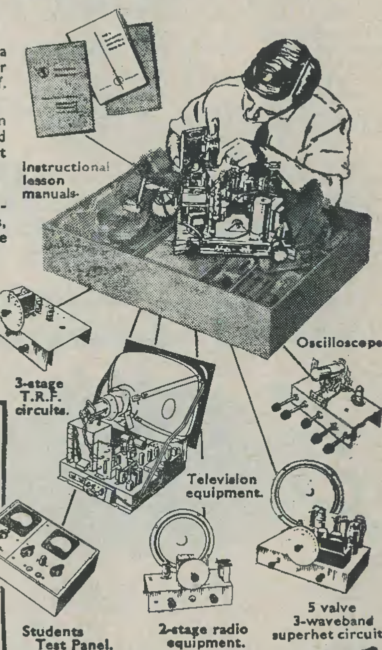

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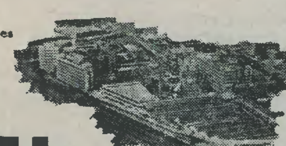

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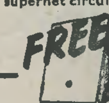

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Editor
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NOTICES

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

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

QUERIES. 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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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*

No. 89 An Inexpensive Insulation Tester

An extremely useful instrument in general electrical and radio work is the insulation tester. Such an instrument may be employed for detecting leakage in wiring, or for checking the insulation resistance of condensers and similar components. With the advent of printed circuit techniques, an insulation tester becomes especially useful for locating leakage between conductors on a circuit board.

Conventional insulation testers are available commercially but have the disadvantage that their relatively high cost makes their use uneconomic when only occasional checks are required. For amateur use something rather cheaper is desirable, and a suggested circuit for an inexpensive unit is discussed in this month's contribution. The tester to be described should be capable of providing a reasonably high degree of accuracy and it has the advantages of employing standard components and of being easily calibrated. Its range extends from 100kΩ to 100MΩ.

The Circuit

The circuit of the insulation tester is given in Fig. 1, and it is necessary to discuss it in some detail if its functioning is to be fully understood.

It will be noted that a simple power supply offering a d.c. voltage of some 300 to 350 volts is provided by the mains transformer, the half-wave rectifier W_1, and the 8μF electrolytic condenser C_1. The current drain incurred by the tester circuit is only of the order of 7mA, with the result that a mains transformer secondary voltage of 250 r.m.s. will probably be quite capable of offering the d.c. voltage required. Provided that complete isolation from the mains and from earth is given, any other power source offering the requisite voltage could be employed instead of that illustrated.

The tester section proper constitutes the remainder of the circuit. This section functions somewhat in the form of a bridge. The component or circuit whose insulation resistance is to be tested is connected across the test terminals. The voltage across these terminals then takes up a value which bears a relationship to the insulation resistance and the series resistor R_6 or R_7 (according to which range is selected). The slider of potentiometer R_4 is then adjusted, following a procedure to be described below, such that the neon bulb just strikes; whereupon the value of the insulation resistance may be read directly from its scale. The purpose of the preset variable resistors R_1 and R_2 is that of ensuring that the voltage range covered by the potentiometer provided by R_6 (or R_7) and the resistance across the test terminals is higher than the range covered by R_4 by a voltage equal to the striking voltage of the neon.

This process may be more readily understood if we take a numerical example. Let us assume, as we do in Fig. 2, that the voltage provided by the power supply is 350, and that the neon strikes at 50 volts. If we then adjust R_2 such that a potential of 50 volts appears across the points A and C in the circuit, the voltage appearing across the potentiometer given by R_6 (or R_7) and the insulation resistance under test, at points C and D, will be 50 and 350 (above A) respectively. At the same time, if we adjust R_1 such that it drops a voltage of 50, then the voltage appearing across R_4, at points A and B, will be 0 and 300 respectively. We will, in other words, have what is effectively a bridge, of which one half is made up by R_4 and the other half by the potentiometer between points C and D. The bridge is balanced by adjusting R_4, balance occurring when 50 volts appears between the two arms.* The value of the insulation resistance under test can then be calculated from the position of the slider of R_4.

As has been stated, the indication of balance is provided by the striking of the neon bulb, and it is important to note that this striking voltage is higher than the voltage at which the neon extinguishes. The resistor R_5 is included in circuit in order to provide a minimum value of resistance in series with the neon regardless of the setting of R_4 or the impedance of the external circuit being checked. The condensers C_2 and C_3 are included to ensure that the neon will strike reliably even when the resistance contributed by R_4, R_6 (or R_7) and the insulation resistance under test is so high that striking would not normally occur. In the event of high values of resistance appearing in the circuit, C_2 and C_3 charge up to the potentials selected by the two potentiometers of the bridge. If these potentials differ by the striking voltage the condensers will then discharge into the neon, causing it to become illuminated. It is possible, when relatively insensitive neons are employed, that the current consumed by the neon will be sufficient to so discharge the condensers that it becomes extinguished again. However, if this happens the condensers will immediately commence to re-charge, causing the neon to strike once more and initiate a further discharge/charge cycle. Summing up, it can be said that the purpose of C_2 and C_3 is that of ensuring that the neon strikes regardless of whatever resistance is in circuit. When the circuit resistance is high, a relatively insensitive neon will flash at regular intervals rather than remain steadily illuminated. This will not, of course, impair the accuracy of the tester, whose reference is the neon striking voltage only.

It is worth pointing out that a factor affecting the accuracy of the tester is that an unstabilised d.c. supply is employed. If bridge balance were indicated by a zero voltage between the two arms of the bridge, varying supply voltages would have no effect on accuracy. As, however, balance occurs

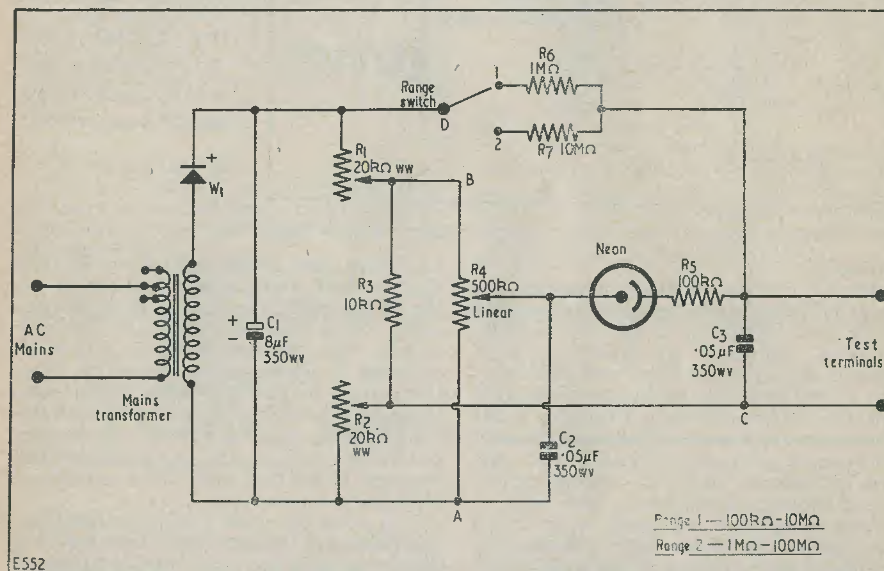


Fig. 1. The circuit of the tester

* It is possible for two positions of balance to be given by R_4 when the voltage from the right-hand part of the bridge is low. The correct balance position in R_4 is that lower down the track, and the procedure employed for taking measurements ensures that this balance is always obtained. A diode in series with the neon could obviate the second balance position, but this increases the cost and complexity of the device.

when a fixed potential difference appears between the two arms some degree of error will occur if the unit is operated from mains supplies having voltages markedly different from that on which it was originally set up. It is a simple matter to re-set the unit for different mains voltages should this become necessary (whereupon the calibration becomes fully accurate again), but it is anticipated that in most instances the unit will be run from mains supplies having the same voltage as that on which it was first set up.

slider of R_4 to the top of its track. Adjust R_1 until the neon is just extinguished. Since the settings of R_1 and R_2 are interdependent it is advisable to repeat the setting-up procedure at least once again before carrying on to the next steps.

Having set up R_1 and R_2, fit a temporary scale to R_4 and mark the minimum and maximum points of its useful range. The minimum point is that at which, with test terminals short circuited, the neon just strikes as the slider travels downwards. The

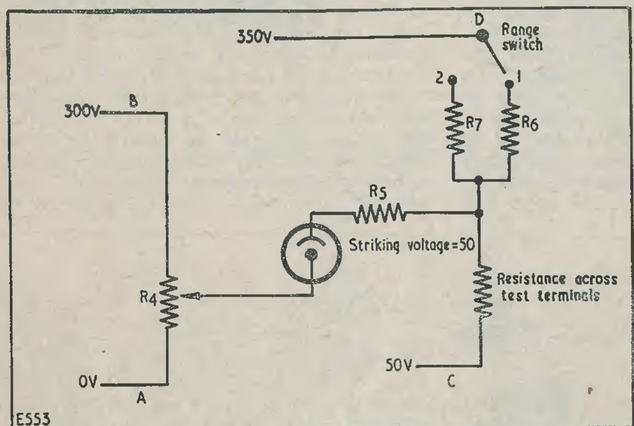


Fig. 2. The basic bridge section of the tester. The voltages quoted are assumed

Setting Up

When the writer originally conceived the design of the insulation tester he had intended fitting fixed resistors in the R_1 and R_2 positions. However, the values of such resistors would be so critical, and their selection so difficult, that he decided eventually that it would be much easier to employ preset potentiometers instead. The use of preset components gives the advantage that long-term changes in value of R_4, which may be caused by wear, can be readily taken up.

After completion, the tester is set up by carrying out the following procedure. Set the range switch to range 1 and short-circuit the test terminals. Adjust R_2 such that the striking voltage just appears across the neon when the slider of R_4 is at the bottom of its track. The easiest method of making this adjustment consists of setting the sliders of both R_4 and R_2 to the bottom of their tracks, and of advancing R_2 slowly until the neon just strikes. The accuracy of this setting can be checked by advancing R_4 until the neon becomes extinguished. The neon should, then, only strike when the slider of R_4 is returned to the bottom of its track. Next, open-circuit the test terminals and set the maximum point of the useful range of R_4 is that at which, starting with the slider at the top of the track, the neon is just caused to strike when the test terminals are open circuit. The range switch should next be set to range 2, whereupon it should be found that maximum and minimum points occur at the same settings of R_4. If it is found that the maximum point on range 2 is lower than occurs on range 1, this indicates leakiness between the test terminals; the most probable fault being leakiness in C_3.

It is advisable, when finding the maximum useful point, to allow a short time for C_3 to charge up after the test terminals have been open circuited.

Calibration

The calibration of the tester is fairly simple as, once the maximum and minimum useful points have been found, the scale of R_4 may be marked directly in terms of resistance with the aid of a protractor. The table accompanying this article gives "spot" resistance values which correspond to certain fractions of the angle between maximum and minimum points. The fractions given in the table define the angle between the appropriate scale indication and the maximum useful point. Thus, if it is found that the angle between the maximum and minimum points is 300 degrees, the 4MΩ (40MΩ on range 2) setting occurs 60 degrees (one-fifth of 300 degrees) from the maximum useful point. It is assumed that inaccuracies in R_4 preclude the use of the extreme end of its track.

Operation

After the tester has been completed and calibrated it is employed in the following manner. First, set the slider of R_4 to the bottom of its track and connect the test terminals to the circuit or component it is desired to check. Advance R_4 until the neon becomes extinguished. Return R_4 until the neon strikes, this being indicated either as a steady glow or as a series of flashes (for the reasons given above). The value of the resistance across the test terminals is that indicated on the scale of R_4.

It should be borne in mind that it is advisable to allow a short time to elapse after connecting the instrument to the test circuit or component when the resistance of the latter is liable to be very high. This ensures that C_3 charges to the correct potential. When the insulation resistance of condensers is being tested, it is necessary to allow further time for these to charge up.

Constructional Details

The tester should not raise too many problems for the experienced constructor, but there are one or two minor points which require emphasis.

Fraction of useful range (from max.)	*Resistance*	
	Range 1	*Range* 2
0	Infinity	Infinity
1/11th	10MΩ	100MΩ
1/9th	8MΩ	80MΩ
1/7th	6MΩ	60MΩ
1/5th	4MΩ	40MΩ
1/3rd	2MΩ	20MΩ
$\frac{1}{2}$	1MΩ	10MΩ
2/3rds	500kΩ	5MΩ
4/5ths	250kΩ	2.5MΩ
5/6ths	200kΩ	2MΩ
10/11ths	100kΩ	1MΩ
1	Zero	Zero

Table 1

The neon bulb employed should be a sensitive unit, preferably of the miniature instrument type. It is, of course, important to ensure that both C_2 and C_3 are high-grade components having the highest possible values of insulation resistance. Metal-cased paper condensers of reliable manufacture and source are advised here.

It will be noted that no chassis connection is shown in the chassis, the reason being that none is needed. A chassis connection could, indeed, reduce the usefulness of the tester. A high quality insulating material is essential for mounting the test terminals.

TRADE *review*

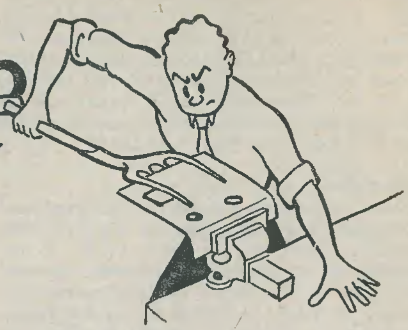
Messrs. R. Fagelston, of 46 Hardwicke Road, London, N.13, have sent us samples of three miniature potentiometers which they are now able to supply. All three are of a size well suited to transistor equipment.

The first is of the preset type, with the track exposed and a slotted bakelite spindle of just over $\frac{3}{16}$in diameter. A small knob could be fitted if desired, as the spindle projects $\frac{1}{8}$in from the mounting bush—the latter requires a $\frac{1}{4}$in diam. hole. The overall diameter is $\frac{3}{4}$in. The resistance is 5kΩ, and the retail price 2s. 6d.

The second sample has the track enclosed within a smart white plastic knob, the diameter of which is $\frac{11}{16}$in and depth $\frac{1}{4}$in. The tags are on a paxolin disc immediately behind the knob, this disc having two lugs with 8BA holes for mounting purposes. Values available are 47kΩ and 1MΩ, and the retail price is again 2s. 6d.

The third potentiometer is of normal design with a spindle of steel $\frac{1}{4}$in diam. and length $2\frac{1}{8}$in from bush. The metal casing is $\frac{13}{16}$in diam., and overall depth (less tags which project from rear) behind panel $\frac{3}{8}$in. The clearance hole for brass bush is $\frac{5}{16}$in diam. This model is available in values of 500kΩ, 1MΩ and 2MΩ, and it retails at 4s. 3d.

IN YOUR WORKSHOP



Aided by his able assistant, Dick, Smithy the Serviceman continues to run the Workshop.

"I THINK," SAID SMITHY PORTENTOUSLY, "that it is high time I started to put you wise on some of the Facts of Life."

"Fair enough," replied Dick complacently, "I'll do my best to help you out."

Smithy the Serviceman and his assistant Dick had just sat down to their eleven o'clock cup of tea, this representing a short break from work which they both appreciated and which was often used by Smithy for the dissemination of technical information.

"Well, I don't think I need your assistance on the subject *you're* thinking of," grinned Smithy. "The facts of life that I want to talk about are those which appear when the young serviceman leaves the shelter of his workshop and goes out into the hard outside world. Especially, in fact, when he meets the customers in their own homes."

"Aw, shucks," said Dick, assuming a look of disgust. "Just as I was preparing one of my two *really* embarrassing questions. Still, never mind; there will be plenty of occasions in the future. For the present, I presume that it's radio alone which rears its ugly head."

"I'm afraid that's so," chuckled Smithy. "What I have at the back of my mind is the fact that, due to you now being capable of repairing two sets for every one that you ruin, you have assumed a certain commercial worth. In consequence the time is very shortly approaching when you will represent the firm as a fixer of sets *in situ*."

"In where?"

"In the houses in which they are installed."

Set-side Manner

Dick looked interested.

"Well, after first of all gracefully thanking you for your unqualified praise of my abilities," he remarked, "I must say that I would honestly look forward to work of that kind. When I first started coming here it was my proud boast that I had built a crystal receiver. I certainly seem to have advanced from that stage."

"You have indeed," replied Smithy, "and the only reason why you haven't done any jobs outside before is merely that I thought it would be better if you first of all built up some confidence in your own ability."

"Is confidence so important?" asked Dick.

"Where relations with the customer are concerned, it is to my mind one of the most important things of all," replied Smithy. "And by confidence I don't mean big-headedness, and the use of a lot of impressive technical words. I mean the confidence you have when you know you can do a job properly, honestly, and without panic.

"Before going on, however, I think I should just utter a few well-chosen words concerning the whole business of servicing in the customer's house. In this country most servicing is done in the workshop, faulty receivers usually being taken there from the customer's house for purposes of repair. It isn't always economic, however, to lug dirty great t.v. sets back to the shop if all that is wrong with them is a faulty valve or something of that nature. With the result that most servicing organisations have an engineer who gives the set a quick look-over for simple snags which can be fixed on the spot, before he brings it back to the bench.

"From what I read about American servicing practice, by the way, it would seem that, over there, much more complicated work is carried out in the home right under the customer's nose than is attempted here. An American service engineer is quite liable to arrive at a house, lay a special canvas sheet on the floor to catch odds and ends, and have the set right down to pieces on the spot. I don't quite understand why this technique is used, because it must make working on difficult snags very much harder. It's one thing to have a chassis on the bench and be able to get at it comfortably and without interruptions. The very thought of the alternative—stooping over a chassis on the floor whilst chasing a bad snag—is enough to make my back ache!

"Anyway, we're getting off my original point."

"Which was," Dick reminded him gently, "that it is important to have confidence in your own ability when tackling sets in their owners' houses."

"That's right," replied Smithy, "and the reason for the importance of this particular point is that such confidence is reflected at once in the engineer's attitude. If a serviceman thinks he cannot cope on a particular job his lack of self-reliance sticks out a mile, and will be noticed by all but the most unobservant of people.

"Another most important point in customer relations is that, having confidence in your ability to do a good job, you must always go ahead and *do* a good job. Slapdash work never pays off, even if it may help you to achieve quick and spectacular repairs every now and again. You must always guard against having people ringing up to say that 'their set has never been right since your young man had a look at it'. It is quite difficult to maintain a reputation for *perfect* servicing because, however well you do a job, you can never be certain that it may not pack up again a few days later because of something entirely different from that which you fixed!

"Yet another point is that it is always a good plan to try and put yourself in the mind of the customer. He has, perhaps, spent some sixty quid or so of his hard-earned money on what he looks upon as a box of magic which provides pictures and entertainment. Every time he looks at that set the figure '£60' looms up at the back of his mind, and quite possibly colours even the pictures which the set provides. Not only does he fear the idea of an incompetent person tinkering with the mysterious innards of his receiver, but he is also very liable to judge that person's ability in terms which he himself can see and understand. You can, for instance, spend quite a long time on a really intricate fault in, say, a video a.g.c. circuit. But if, after clearing the set, you put only four screws into the back when originally there were eight, then the customer will very likely classify you as someone who skimps his job. As you know, I've always made a special point of ensuring that the backs of all sets leaving the Workshop have a full complement of screws wherever possible, even if they came in with some missing. I'm convinced that it pays dividends."

"I suppose," Dick interjected, "that your rigid practice of giving the cabinet a bit of a rub after the set has been repaired is also for the same reason."

"That's right," said Smithy. "One of the first rules of servicing is that a set always works better when the cabinet has a nice shine on it! It doesn't take two minutes to give the box a bit of a polish, or to blow any dust out of speaker grilles and things like that, and it gives the customer a very good impression indeed. He may have to fork out for a replacement component whose function he cannot comprehend but, if the cabinet has been polished, he does at least have the satisfaction that the set *looks* obviously better after it has been through the workshop than it did before."

"So far as I can see," remarked Dick, just a little too seriously, "if you want to succeed in this servicing lark all that you have to do is to put twice as many screws into the backs than the sets should have and to polish up the cabinets like billy-o. There's no need to bother with the works at all!"

Smithy chuckled.

"I shall ignore that comment," he said, "and return to the subject. It might be worth while giving a warning, though, that you should always use a good quality product when polishing cabinets. I heard of a serviceman recently who was using some stuff he happened 'to have on hand' on a radio cabinet, and who accidently dropped some of this on to the tuning scale. The latter was made of Perspex, which promptly commenced to dissolve! So, take warning."

"Fair enough," said Dick. "Any other tips in this business of customer relations?"

"I have hundreds," said Smithy, "and I could go on for hours on the subject. However, if I do I shall be entering into character studies and I don't want to do that at this stage. Before finishing, nevertheless, I think I should remark on one or two of the less important general points which should be remembered.

"One of these concerns the business of getting a set back to factory state. Quite often a receiver gradually becomes more and more unserviceable in the customer's home as the years roll by; but it is only when it ceases working altogether that the owner finally decides to get somebody to have a look at it. In such cases, the serviceman may be faced with two alternatives in getting the set back into working order. Firstly, he can fix the fault which finally caused the set to stop working and then leave it in the state it was in before that fault occurred. Or, after curing the final fault, he can set about the longer job of getting the receiver back to its initial factory performance. I normally try to follow the second line of action, provided that the cost of the extra servicing involved is not too great. In practice, such a policy can usually be carried out fairly easily. If, however, the cost of the extra servicing is liable to be excessively high, I try and explain the problem to the customer, whereupon he makes his own decision. This procedure has two advantages. In the first place, when you clear all the outstanding faults without incurring too heavy a cost, the customer is usually quite highly impressed. In the second case he is pleased at the fact that you have taken him into your confidence. I won't say that *every* customer will be pleased with your efforts in this respect because there is always a small number who would not be satisfied if you repaired their sets for nothing. But you would keep the vast majority happy.

"Another minor point concerns the business of explaining technical points to non-technical people. The only advice I can offer here is to try and keep your explanation as simple as possible. I think that one of the best examples of a good approach to this problem was one I heard about recently. A serviceman was trying to explain to an old lady why there was a spot on the screen of her television receiver after she switched it off, and how she could clear it by momentarily increasing brilliance just after turning the on-off switch. After several attempts he finally said: 'What happens in the set is that there is still some electricity left in the tube after you switch off, and it is this which causes the spot to appear. If you turn the brilliance control up for a moment just after switching off you use up all that electricity and the spot disappears.' Whereupon he was amazed to hear the old lady say that she now understood what he meant perfectly, and why hadn't he put it like that before? It wasn't until later on in the day that the serviceman realised how exactly right, in a technical sense, his 'simplified' explanation had been!"

Dick chuckled.

"It would appear," he remarked, "that a good engineer is a psychologist first and a serviceman second."

"My only comment on that," replied Smithy, "is to add that a little common sense plus a little appreciation of the other person's point of view will always help anyone, whatever his walk of life."

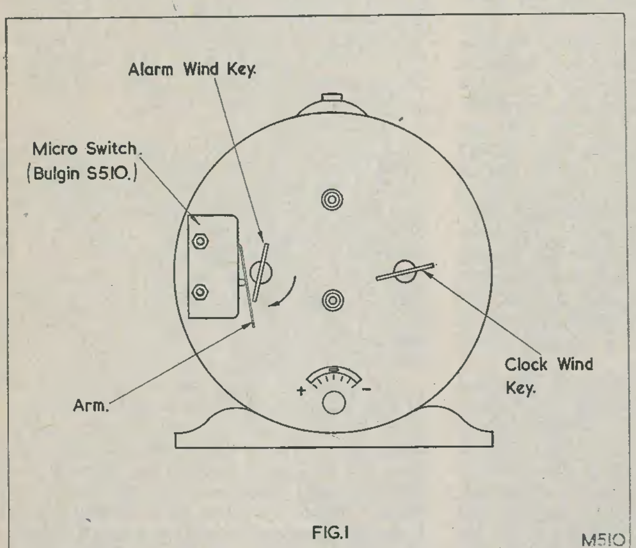


Fig. 1. How a micro-switch may be fitted to the back of a standard clock in order to provide an alarm switch. The arrow indicates the direction in which the alarm key rotates when it unwinds

Another Alarm Switch

Smithy replaced his cup of tea on the battered Workshop tray, and made obvious preparations for a return to his bench.

"Just a moment," said Dick, "but can I ask a quick question on another subject altogether? Do you remember, some time ago,* that you described a simple alarm clock switching device which turned on the radio in the morning? It was a gadget which used a relay and switching contacts in the clock."

"I do," said Smithy, a little guardedly.

"I seem to recall," continued Dick, "that you said a couple of days ago that you had heard of a much simpler method of doing the same job. You didn't give me any details then, and I've been curious about it ever since."

Smithy returned to his chair.

"Well, if you're really interested, there's no reason at all why I shouldn't tell you about it now. This different method of switching on a radio in the morning isn't my own idea, by the way, and it is so delightfully simple and reliable that it deserves full consideration by anyone who wants to take advantage of it.†

"This particular early-morning switching device consists quite simply of a Bulgin micro-switch type S.510 fitted to the back of a standard Smith's alarm clock with the aid of two 6BA screws (Fig. 1). The micro-switch is mounted such that, when the alarm operates, the alarm key unwinds and bears against the arm of the micro-switch, thereby switching it on."

"That appears simple enough," commented Dick. "Does the micro-switch arm prevent the alarm key from turning any further?"

"That's right," replied Smithy. "Before you initially complete the assembly of the device you wind the alarm spring up by approximately half to three-quarters. When the alarm operates, the key then traverses the small angle needed to operate the micro-switch, after which the latter prevents it from travelling further. To reset the alarm you merely turn the key one 'click' or so in the winding direction, whereupon the micro-switch is released and is ready for the next operation."

"But doesn't that mean that the alarm spring is never allowed to become fully unwound?"

"That's perfectly true, but I understand that this should cause no complications. I might add that the designer of the device has had it in constant use for over five years, so there shouldn't be any need to worry about any harmful effects on the spring. I might add, incidentally, that he not only uses the alarm switch to turn on the radio but also to switch on a light over his bed *and* one of those proprietary tea-making gadgets."

"Well, that's luxury indeed!" remarked Dick, impressed. "By the way, how do you fix the micro-switch to the alarm clock case?"

"The method of fixing will differ for different makes and designs," replied Smithy, "but in the case of the standard Smith's clock you can do it with the two 6BA screws I mentioned just now. You first of all take the back off the clock, drill a couple of 6BA clearance holes in it, and fit two 1in 6BA screws with threads outermost (Fig. 2). You then pop the micro-switch over the screws, fit a couple more nuts—with washers preferably—and Bob's your uncle."

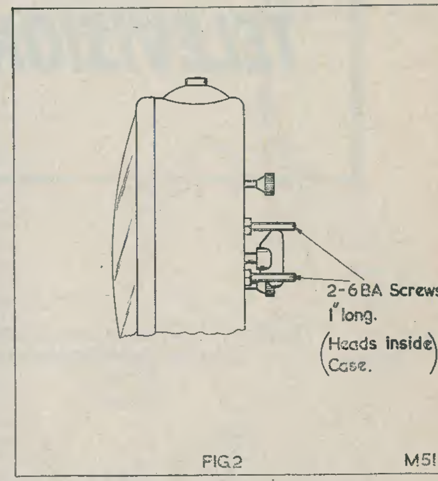


Fig. 2. Preparatory to mounting the micro-switch, the 6BA screws are fitted to the clock back as shown here

"With which remark," said Dick, "I am not in the least disposed to disagree."

"I'll disentangle that sentence later," smiled Smithy. "Perhaps I should have said instead that Fanny's your aunt."

"Which brings us," replied Dick, standing up and walking over to his bench, "back to the facts of life all over again."

New Catalogue

Sam Mozer Ltd. have sent us a copy of their new catalogue listing Ardente products for which they are now, as announced elsewhere in this issue, the sole distributors to the trade. The catalogue may be obtained by readers from most retail dealers. It is well produced and should form a most useful reference, as it contains a wealth of technical data regarding Ardente products which has not hitherto been freely available to enthusiasts.

* In Your Workshop, *The Radio Constructor*, Dec. 1957

† This alarm switch was devised by reader H. G. Lever, Pinner, Middlesex

UNDERSTANDING TELEVISION

PART 5

By **W. G. MORLEY**

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

In the first four articles in this series we examined a number of aspects of television communication when considered in terms of the signal which is handled by the television system. The last two articles gave up-to-date information on the waveforms employed in the major television services in the world, quite a considerable amount of detail being provided in order that reference may be made to such systems at later stages in these articles. The writer would like to point out that the last two contributions were originally conceived as a single article but that, due to the rather large amount of matter contained therein, this had to be published in two successive issues.

Having laid our groundwork with the television waveform, we can now proceed to particular sections of the television system including especially those parts which may already be familiar to us in the domestic television receiver. This month we shall start with the cathode ray tube.

The Cathode Ray Tube

In just the same way as a sound receiver requires a loudspeaker in order that the electrical signals it handles may be converted to audible sounds, so does the television receiver require a device capable of translating electrical signals into visual form. The device which is now universally accepted for the presentation of television pictures is the *cathode ray tube* (c.r.t.) or *picture tube*.[1] The process of displaying a television picture on the screen of a cathode ray tube is, however, rather more complex than is that involved in causing sounds to be provided by a loudspeaker. In the latter case the electrical signal is applied directly to the two terminals of the loudspeaker, whereupon this provides an audible sound which, within its limits, is equivalent to the electrical input. In the cathode ray tube video information may be similarly fed to two terminals (the grid and cathode of the tube) but this signal only controls the strength of an electron beam. For the complete picture to be built up, the beam has to be deflected over the scanning pattern required by the particular system employed, and it has to be *focused* such that, whatever its position at any particular moment, it falls only on to a very small area of the screen.

Fig. 21 illustrates the fundamental make-up of a cathode ray tube of the type used in television receivers. As may be seen, the whole assembly is housed in an evacuated

[1] In American terminology the cathode ray tube is often referred to as a *kinescope*.

glass envelope, the three major parts of which are the *neck*, the *cone* and the *screen*.[2] The cone and the screen are sometimes described, together, as the *bulb* of the tube. During manufacture the neck, cone and screen are fused together, using fairly conventional glass-welding techniques. In some cathode ray tubes the cone is made of metal, in which case joints between this cone and the glass neck, and the glass screen, are made with the aid of special glass-to-metal sealing methods.

Connections to the electrodes inside the glass envelope are made at two points. Lead-outs from electrodes requiring relatively low potentials—such as heater, cathode and grid, etc.—are brought out from the neck to the *base*, being terminated normally in pins mounted in a moulding similar to that employed for glass octal valves. The conventional base for television cathode ray tubes is the *duodecal* base, this having twelve pins spaced around a central keyed spigot. Since it is very rarely that all twelve pins are needed for connections to electrodes, a number are frequently omitted from the base assembly. In some cathode ray tubes (not necessarily those intended for television receiver purposes) the lead-outs take up the form of pins fitted in the glass, offering a pin mounting similar to that used in "all-glass" B7G and B9A valves.

Connections to electrodes requiring very high potentials cannot be taken out at the base, owing to the risk of flashover to neighbouring lead-outs. In television receiver cathode ray tubes there is only one electrode which requires a high potential, and a connection for this is fused into the side of the cone. With metal-coned cathode ray tubes, high potential connections are made via the metal cone itself.

The Electron Gun

Inside the neck of the cathode ray tube is an electrode assembly called the *electron gun*, or, more simply, the *gun*. This name is aptly chosen because it is the function of the gun to emit a narrow beam of electrons towards the screen. In its simplest form the gun takes up the appearance illustrated in Fig. 22. At the left-hand end of the gun assembly we have a cathode which is raised to a high temperature by means of the heater. The centre of the cathode surface is coated with emissive material which causes electrons to be emitted towards the grid. The grid consists of a cup-like element which surrounds the emissive surface of the cathode, and which has a small hole in its centre to allow electrons from that cathode to pass through to the anode. Since the grid is normally held negative with respect to cathode, electrons from the latter are repelled by the inside walls of the grid and can only pass through the hole in its centre. The number of electrons which may pass through is regulated by the negative potential on the grid, with the result that a control of the number of electrons travelling towards the anode may be obtained by varying this potential. It is due to its ability to control electron flow that the grid is so called despite the fact that it does not take up a form equivalent to that in a conventional valve.

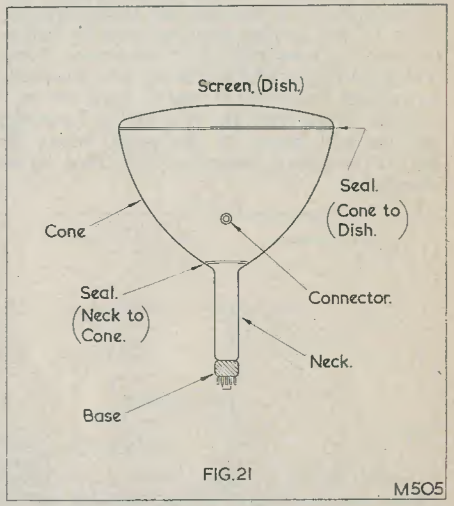


Fig. 21. The component parts of the cathode ray tube envelope

After passing through the grid aperture the electrons proceed towards the anode, this having a very high positive potential with respect to cathode. The anode has a cylindrical shape, and has one or more sections with central holes through which electrons may pass. Due to the very high potential of the anode the velocity of the electrons leaving the grid aperture is increased very greatly, whereupon a large proportion of them are liable to pass through the hole, or holes, in the anode, and carry on to strike the screen of the cathode ray tube. Some of the electrons fall directly on to the walls of the anode whereupon they return to cathode via the power supply providing the anode potential.

The electrode construction shown in Fig. 22 is that employed in what is often called a "triode" assembly. A construction which is more frequently employed includes a *first*

[2] The screen section may be referred to, during manufacture, as the *dish*.

anode and a *second anode*, and is sometimes described as a "tetrode" assembly. Such an assembly is illustrated in Fig. 23. In this diagram the first anode is provided with a potential which is, usually, some two to five hundred volts positive with respect to cathode. This anode accelerates the electron stream and helps in making it more convergent. The second anode has a much higher potential applied to it, and it provides a very high degree of acceleration to the electron stream.

Gun assemblies having more than two anodes are constantly encountered, the purpose of the additional anodes being mainly that of providing a convergent beam. In *electrostatic focus* cathode ray tubes, one or more of the anodes may be used to make the electron stream focus at the screen, control of the degree of focus being then obtained by varying the potential held by such anodes. Anodes which serve the purpose of focusing the electron beam at the point where it strikes the screen are sometimes called *focus electrodes.*

Due to the varying number of anodes which may be fitted in different designs of cathode ray tube, it is common practice to refer to the ultimate anode (that having the highest positive potential) as the *final anode.* This obviates the necessity of referring to this electrode by a number which is liable to vary between cathode ray tubes having different gun assemblies but similar performances.

Up to now we have followed the course of the electron stream leaving the cathode, and passing through the grid (and any subsequent anodes in the gun assembly) until it reaches the final anode, but we have not yet discussed the form which that final anode may take. The most usual final anode shape is cylindrical; in which case it may take up the form of a tubular electrode or, more commonly, a conductive layer painted on the inside surface of the glass neck and cone, as shown in Fig. 24. If any electrode in the gun structure proper needs to be held at final anode potential, contact to this internal conductive coating may then be made with the aid of springs fitted to the structure. The conductive coating applied to the internal surface of the tube envelope is almost always Aquadag, this being a colloidal solution of graphite. When, after application, the Aquadag solvent has been allowed to evaporate, a film of graphite remains, this having sufficient conductivity to function as an electrode. It should be mentioned that the current flowing in the final anode circuit is normally of the order of 50 to 200 microamps only, with the result that the material of which the final anode is made requires only a low degree of conductivity.

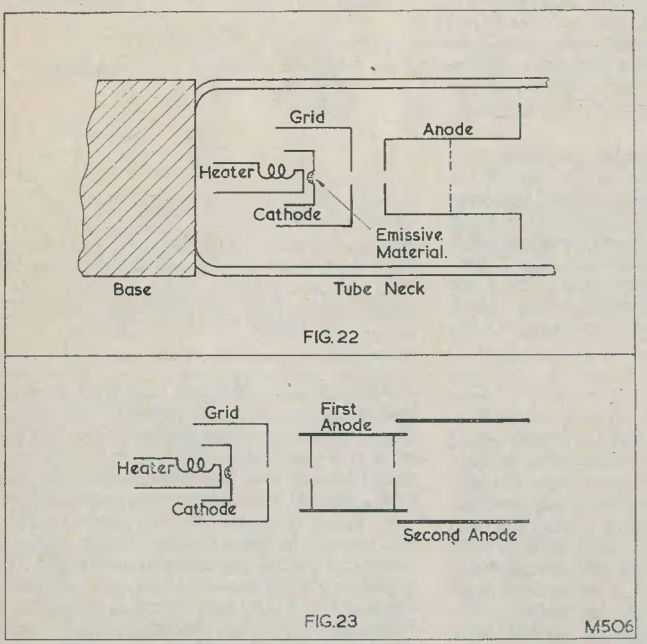


Fig. 22. The electrode assembly in a "triode" electron gun. Fig. 23. A "tetrode" electron gun. The assemblies shown here and in Fig. 22 are not to scale.

The electron beam striking the screen causes fluorescence and consequent radiation of light, and also results in secondary electrons being struck off from the screen material. These secondary electrons are attracted towards the final anode and return, through the final anode supply, to cathode. In consequence an electron circuit is set up: electrons leave the cathode, strike the screen, and release secondary electrons which return via the final anode to cathode.[3]

Cathode Ray Tube Supplies

We have referred, above, to the potentials which are applied to the television cathode ray tube, without giving any very detailed description of their nature. This we may now proceed to do.

Since it is current practice in British television receivers to use "transformerless" power supply circuits wherein the heaters of the valves and the cathode ray tube are connected together in series, present-day television cathode ray tubes employ heaters intended for series operation. The most common cathode ray tube heater current is 0.3 amps, the heater voltage being a conveniently accepted figure, such as 6.3 volts. Earlier cathode ray tubes were liable to have a number of differing heater voltages and currents according to their manufacturers, but such voltages and currents are now mainly encountered in tubes meant for replacement purposes only.

Cathode ray tubes require a fairly large negative grid bias voltage with respect to cathode, and such a bias can be readily obtained by operating the cathode at a voltage which is positive to chassis, this potential being obtained from a potentiometer network connected between the h.t. positive line and chassis. However, the question of grid bias for a cathode ray tube is not quite the same as occurs with a normal amplifying valve, this being due, as we shall see in a later article, to the practical circuitry needed to feed the video signal to the cathode ray tube, and also because the potential between grid and cathode affects the overall brilliance of the picture. It is quite common in practical receivers for the cathode of the tube to be some 100 volts positive to chassis, with the grid having a lower positive potential which then enables it to be negative to the cathode.

If a video signal is applied to it, the grid of a cathode ray tube may be referred to as the "modulating electrode," the reason for this being that it is capable of varying the number of electrons in the cathode ray tube beam—or *modulating* the beam—by reason of the potential applied to it. In a practical receiver the video signal can be applied direct to the grid of the cathode ray tube, the cathode being maintained at a fixed potential. An alternative method of modulating the tube consists of keeping the grid at a fixed potential and of applying the video signal to the *cathode.* Most modern television receivers made in Britain employ cathode modulation, as this results in convenience of design in the video amplifier stage.

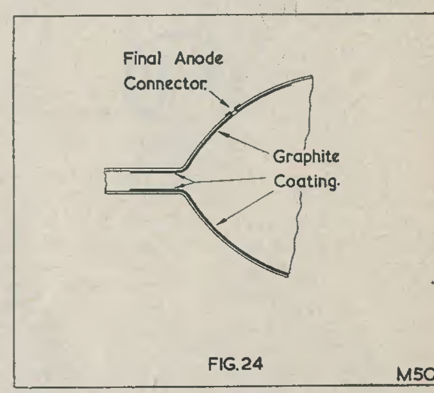


Fig. 24. The final anode of a cathode ray tube may consist of a graphite coating on the inside of the glass envelope

In cathode ray tubes of the "tetrode" type, the first anode normally requires supply potentials which are of the order of 200 to 400 volts positive to cathode. The h.t. positive line in a conventional "transformerless" receiver is usually around 180 to 220 volts (this being obtained by half-wave rectification of the a.c. mains supply) and, whilst this is sufficient for supplying cathode ray tube grid and cathode potentials, it is not high enough for the first anode. Fortunately, modern television receivers derive what is termed the "boosted h.t. supply" from the circuits associated with line deflection, this boosted supply usually offering some 500 volts or so at a limited current. First anode current requirements are very low and so it becomes a simple matter to provide it with the potential it requires by means of a simple resistor potentiometer between the boosted h.t. line and chassis. The boosted h.t. supply may also be used for multi-electrode cathode ray tubes wherein

[3] When very high final anode potentials are employed the secondary electrons lost by the screen may not be equal to those gained from the cathode. The result is that the screen acquires a potential—the "sticking potential"—which is lower than that of the final anode and which adversely affects the efficiency of the tube. This difficulty is dealt with in more detail when aluminised tubes are considered.

other anodes require potentials higher than that available from the normal h.t. positive line.

The final anode of the television cathode ray tube requires a very high potential, this lying somewhere between 5,000 volts (or 5kV) for early nine-inch tubes, to some 17 or 18kV for modern 21-inch tubes. (Projection cathode ray tubes, which have to present a picture which is sufficiently bright for it to be projected on to a remote screen, require final anode voltages of the order of 25kV.) Present-day television receivers employ cathode ray tubes whose screen sizes are 14 to 21 inches, and final anode voltages in the range 14 to 17kV are those which are most commonly encountered.

In company with the boosted h.t. voltage, the final anode supply in a modern receiver is obtained from the circuits associated with line deflection, and it is referred to as the e.h.t. (or extra high tension) voltage. In American terminology the final anode voltage is referred to, quite simply, as "high voltage." Since American usage is to refer to the normal h.t. supply as the B supply,* there is ample differentiation between the two positive potentials.

An interesting point with regard to the e.h.t. supply is that this is normally provided by an e.h.t. rectifier which allows a reservoir condenser to become charged to the e.h.t. voltage when positive voltage pulses from the circuits associated with line deflection are applied (see Fig. 25 (*a*)). The reservoir condenser requires a minimum capacity value of approximately 500pF only and, in early receivers, special high working voltage condensers were fitted for this purpose. However, since the final anode consists of a graphite coating on the inside wall of the cathode ray tube envelope it becomes possible to make this function as one plate of a condenser, the complementary plate being provided by a second coating of graphite on the outside of the glass. The outside coating may be connected to chassis by means of metal springs, whereupon the whole assembly becomes capable of taking the place of the original separate reservoir condenser (see Fig. 25 (*b*)). The glass of the cathode ray tube functions, of course, as the dielectric of the condenser, and it is sufficiently thick to withstand the potential difference between the two conductive coatings without breaking down. It is now common practice to employ outside coatings on cathode ray tubes in order to provide the required e.h.t. reservoir condenser, typical capacity values being of the order of 1,000pF or so.

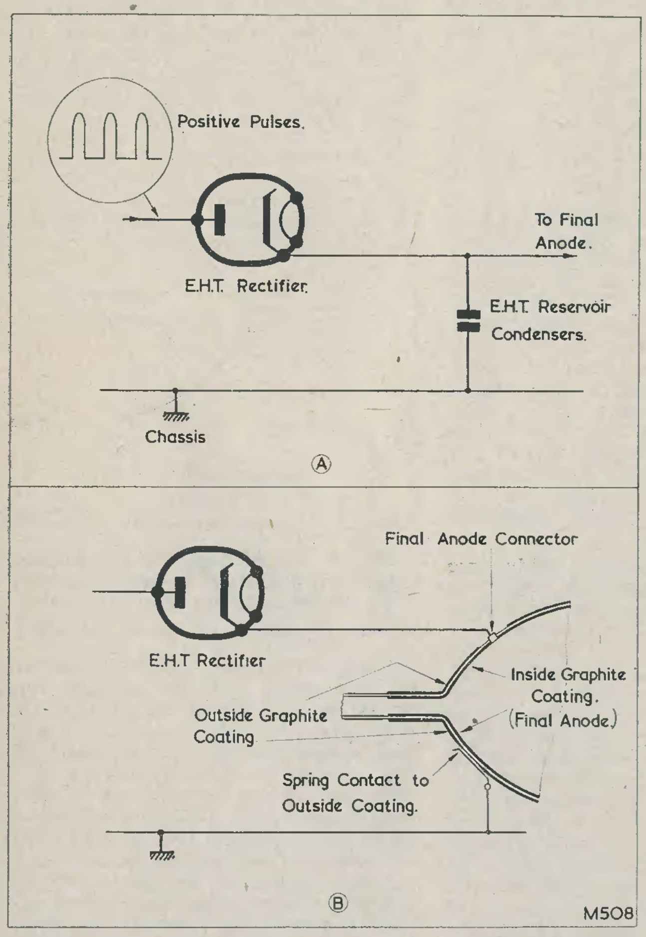


Fig. 25 (a). A conventional e.h.t. supply circuit. (b) By applying a graphite coating to the outside of the glass envelope, an effective reservoir condenser is formed. The final anode provides the complementary plate of the condenser.

* In American terminology the heater, or filament supply is referred to as the A supply; and the grid bias supply, if any, as the C supply.

Cathode Ray Tube Dimensions

Since the commencement of high definition television, cathode ray tubes for receiver purposes have varied considerably in shape and size. Very early cathode ray tubes assumed a shape similar to that illustrated in Fig. 26 (*a*) insofar that they had a round screen and a cone which opened out only gradually from the neck to the screen. Such tubes were often too long to permit of direct viewing owing to limitations in cabinet design, and they were sometimes mounted vertically—whereupon their screens could be viewed via a mirror mounted at 45 degrees to the horizontal. A much later type of tube is that shown in Fig. 26 (*b*), wherein the cone opens out much more abruptly between the neck and the screen. As may be gathered, this type of tube can quite easily be mounted horizontally in a cabinet and provide direct viewing of its screen. The most modern type of tube currently in production has the outline shown in Fig. 26 (*c*), wherein the distance between the neck and the screen is made relatively very small indeed.

In Figs. 26 (*b*) and (*c*) it will be noted that the *deflection angle* of the tube is indicated. As we already know, it is necessary for the electron beam inside the tube to be deflected in order that it may trace out on the screen the line pattern required by the system with which it is used. In practice, the method employed for deflection causes the beam to be shifted at a point near the junction of the neck and the cone. It is assumed, in Figs. 26 (*b*) and (*c*), that this point occurs at the positions designated "deflection centres." The angles existing between the "deflection centres" of Figs. 26 (*b*) and (*c*) and the outside edges of the screens are then indicated as the deflection angle of the tube. (The deflection centres shown in Figs. 26 (*b*) and (*c*) are positioned as far back from the screen as is possible. If they were positioned further back, the electron stream, after deflection, would be prevented from reaching the edges of the screen due to its path being physically impeded by the corner between the neck and the cone. It is possible to have the deflection centres—whose positions are governed by components outside the tube envelope—further forward towards the screen than those shown in Figs. 26 (*a*) and (*b*).)

Up to 1953 and 1954 the television cathode ray tubes commonly employed in Great Britain consisted of developments and improvements on the type shown in Fig. 26 (*a*), and, for many years, had nominal deflection angles of 50 degrees. Seventy degree (nominal) tubes were then introduced, these having the form shown in Fig. 26 (*b*). Around the same time the circular screen was replaced by the rectangular screen, with a consequent saving of volume, weight and glass. British television receiver manufacture has now changed over very largely to 90 degree tubes, whilst American manufacture includes a proportion of 110 degree tubes, these being similar to that illustrated in Fig. 26 (*c*).

The reason for the continual advance in cathode ray tube design towards greater deflection angles is almost entirely one of economics. It will be readily understood that when the deflection angle increases the overall length of the tube becomes shorter for a given size of screen, with the consequence that the cabinet in which the tube is housed may become smaller also. Smaller cabinets result in a saving in cost; not only in materials, but also in shipping and handling. Similarly, a shorter tube results in a saving in glass and smaller tube dimensions. This latter advantage is more considerable than may at first sight appear because, apart from the not entirely unimportant cost of the glass itself, less glass means less weight and, again, reduced shipping and handling charges. The importance of cathode ray tube shipping costs becomes very evident when it is realised that a tube, in its carton, is not very much smaller than the television receiver into which it is fitted.

The development of cathode ray tubes up to the current deflection angle of 110 degrees has been a somewhat slow process, this being due to two major difficulties. The first of these is that the glasswork of the tube is liable to become structurally weaker insofar

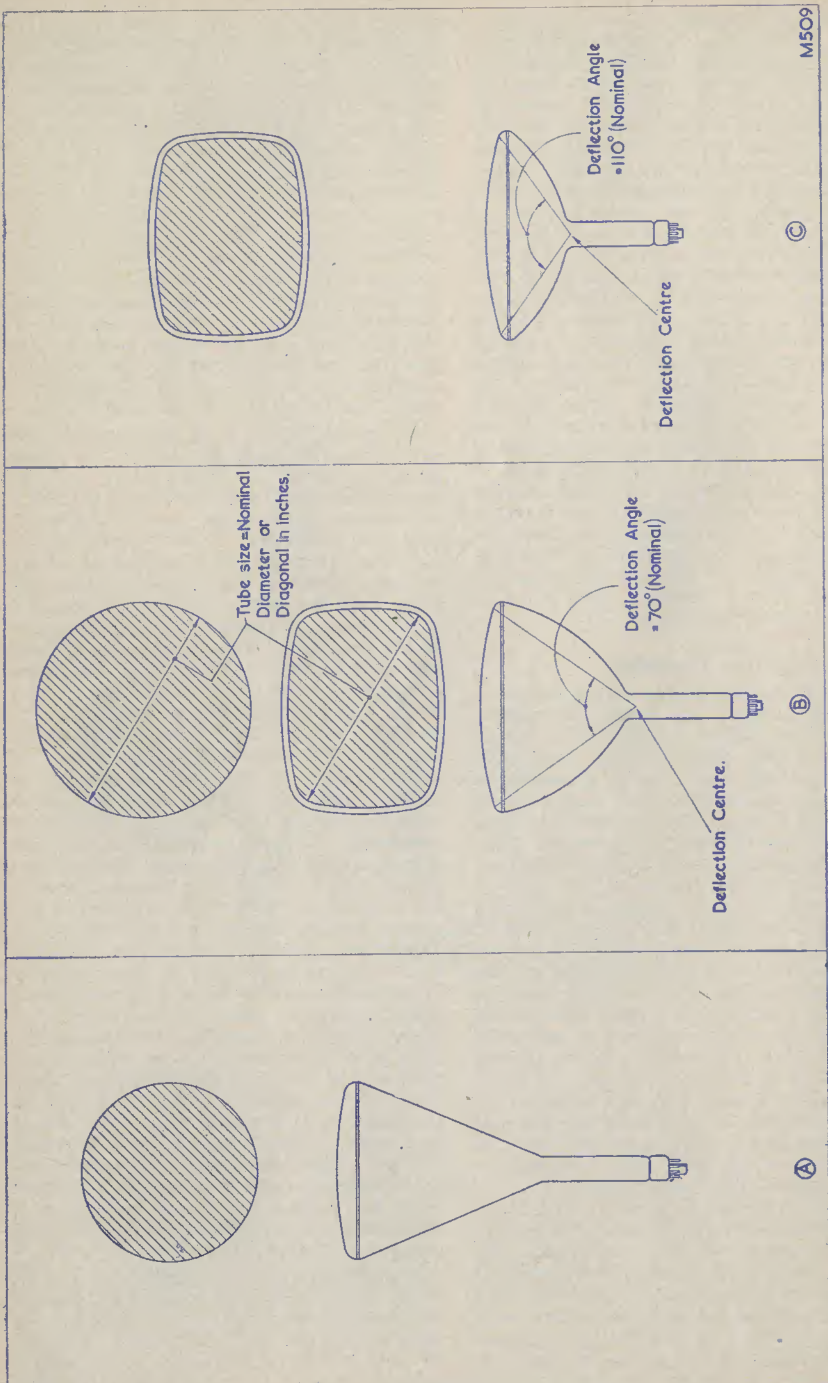


Fig. 26. The progress in cathode ray tube design towards larger deflection angles. The tube shown in (a) is typical of very early designs, whilst that in (b) was introduced some four or five years ago. The change from round to rectangular screens occurred about this time. The tube illustrated in (c) has a deflection angle of 110 degrees

as its ability to withstand atmospheric pressure is concerned when the deflection angle is increased, and careful design is required to overcome this risk. (As may be seen, the screen of the 110 degree tube, illustrated in Fig. 26 (*c*) is somewhat more curved than that of Fig. 26 (*b*), this being largely due to the need for structural strength.) Secondly, the introduction of greater deflection angles places considerable demands on the components and circuits which deflect the beam, and special materials and manufacturing methods have had to be developed to meet these demands. However, we shall deal with this particular point in a later article.

A minor point of terminology is worth recording. When 70 degree tubes were first introduced in Britain they were referred to as "wide-angle" tubes, the earlier 50 degree tubes being described as "narrow-angle" tubes. Although these two terms have now become meaningless with the introduction of 90 degree tubes they are still employed occasionally. Whether, in current references, "wide-angle" refers nowadays to 70 degree or 90 degree tubes is anybody's guess.

Apart from deflection angle, a second important cathode ray tube dimension is its screen size. This is the nominal dimension, in inches, of the diameter of a round screen, or the *diagonal* of a rectangular screen (see Fig. 26 (*b*)).

Next Month

In next month's article we shall continue with the cathode ray tube.

MISCELLANEOUS

A Warbling Tone Generator

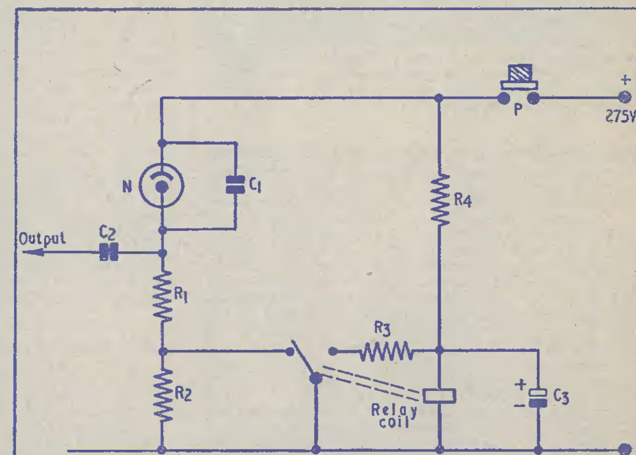
By J. H. BLOOR

IN THE DESIGN OF A WORKS PUBLIC ADDRESS system it was desired to incorporate a means of alerting staff to the imminence of announcements. A tone generated by a neon relaxation oscillator, arranged to warble by means of a slowly vibrating relay, was found both easy to arrange and satisfactorily distinctive in service.

The circuit shows the arrangement used; values are not critical but R_1–R_2 may require adjustment according to the type of neon tube and the h.t. voltage used. The values quoted are suitable for a small tube of the G.E.C. Button Tuneon type, generating a tone of about 1 kc/s frequency with about 100 c/s wobble. Increasing C_1 reduces the frequency.

Pressing the button starts the oscillator, its output being fed into the amplifier by a small capacitor C_2. The relay operates after a short delay due to the slugging effect of C_3; its contact removes the short-circuit from R_2, lowering the frequency by an amount which is a function of the value of R_2. The contact also applies a short-circuit to the relay coil (via R_3 to minimise sparking at the contacts). The relay releases and the frequency rises again; this sequence is repeated as long as the button is pressed.

Any relay of about 5-10mA sensitivity is satisfactory, typical coil resistance being about 2,000 ohms.



A warbling tone generator

Component List

R_1 4.7MΩ ¼W
R_2 470kΩ ¼W
R_3 100Ω ¼W
R_4 22kΩ 3W
C_1 470pF 200V wkg
C_2 220pF 350V wkg
C_3 50μF 50V wkg
N G.E.C. Button Tuneon
Relay approx. 2,000Ω coil, 1 c/o contact
P Push button

Book Reviews

WORKED RADIO CALCULATIONS (2nd Edition). By Alfred T. Witts, A.M.I.E.E. 155 pages, 77 diagrams. Published by Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 12s. 6d.

This is the sort of book that represents good value for money to the student of radio and the experimenter. It is a source of considerable information, and is not likely to spend much of its life mouldering on the bookshelf.

Nine chapters cover a wide field of problems and worked examples, progressively graded from very simple ones to more difficult studies. These deal with current, voltage, resistance, d.c. power, meters, batteries, electromagnetism, inductance, transformers, capacitors and capacitance, reactance, impedance, resonance, simple a.c. theory, thermionic valves, decibels, aerials and feeders, and radio receive circuits. Some calculations on transistor circuits have been included in this new edition. The index proves to be a rapid means of locating any particular example required.

Sufficient explanation of underlying principles and theory is given to convey a clear understanding of some of the less familiar calculations. The work is set out in good orderly fashion, which could be excellent training for those who are preparing to sit for examinations. The reader can also readily comprehend how the examples can be used or adapted for solving his own particular problems.

Examples 109 and 110 could have done with a little more elucidation, if only to show the proofs of the calculations that $\frac{2\times100}{20}=1000$ and $\frac{3\times(6\times90)}{50}=3240$. It is also thought that some mention of time constants, cathode followers and auto-transformers could have been made. However, it is very difficult to decide what should or should not be omitted from a book of this sort, and on the whole the author has covered the reader's need extremely well.

FREQUENCY-MODULATED RADIO (2nd Edition). By K. R. Sturley, PH.D., M.I.E.E., SEN.M.I.R.E. 120 pages, 78 diagrams. Published by George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 15s.

The first edition of this book, reviewed in the December 1956 issue of this journal, covered the principles and practice of f.m. transmission and reception, and provided much useful information concerning the alignment and correct adjustment of receivers. This present edition sees only minor changes in the text, but direct comparison of the two editions was not possible for the purpose of these notes. It is noticed that there are fewer diagrams, so it is possible that certain additions have been made, as distinct from the extra text on pulse type f.m. detectors.

In this latter respect the author briefly describes this form of detection, but points out that it requires a very low intermediate frequency and has comparatively low conversion efficiency.

The standard of production is good, as befits the author's presentation of a subject in which he is well versed.

HOW TELEVISION WORKS. By W. A. Holm. 352 pages, 246 diagrams and illustrations. Published by the Philips Technical Library. Obtainable in England from Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 32s. 6d.

The writer of these notes has had several new books from the Philips Technical Library pass through his hands for the purpose of writing about them in these reviews. He has said before that text-books from this source are good ones: this latest arrival from Eindhoven is certainly no exception.

Written by a German engineer, the book is exceptional in that it describes factually (and extremely clearly) the vast field of technicalities involved in television transmission and reception without using a single mathematical sign or a calculation of any sort. One would hardly think it possible to convey a sufficient understanding of the subject in this way, but it has been done. However, the author does use many graphs, charts and diagrams annotated with symbols to clarify the text, otherwise it is difficult to see how he could have achieved his object by the written word alone.

The main sections of the book deal with principles of picture transmission, electronic scanning, the video signal, oscillations, pulses, thermionic valves, the complete television signal, television reception and projection television. Each of these sections is sub-divided: that on the television receiver, for example, covers general consideration, mixers, r.f., i.f., and video amplifiers, timebases, power supplies, installation and operation. Space here precludes a more detailed list, for to indicate the many sub-divisions would involve reiterating all that is given in the nine pages of contents for the book.

MAGNETIC RECORDING HANDBOOK (2nd Edition). By R. E. B. Hickman, M.B.K.S., M.T.S. 176 pages, 111 diagrams and illustrations. Published by George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 21s.

Like the 1st edition of this book, reviewed in these pages in March 1956, this new edition deals mainly with the theory and development of magnetic recording systems, gives detailed information of several commercial equipments, and devotes space to the maintenance and servicing of recording apparatus.

The author has taken the opportunity to revise and enlarge the text, which now includes some new material on present-day equipment, long-play tapes, and recent developments in the use of magnetic tape for factory production control, etc. There is also some mention of stereosonic tape recording, talking books, and television recording.

A fairly lengthy bibliography provides many references for further reading. Three appendices deal with copyright both before and after 1957, when certain changes became operative, and the standards of recording and reproducing characteristics recommended by the C.C.I.F. The reading matter, and in particular the diagrams and photographs, are well produced.

HIGH FIDELITY SOUND REPRODUCTION. Edited by E. Molloy. 200 pages, 150 diagrams and illustrations. Published by George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 20s.

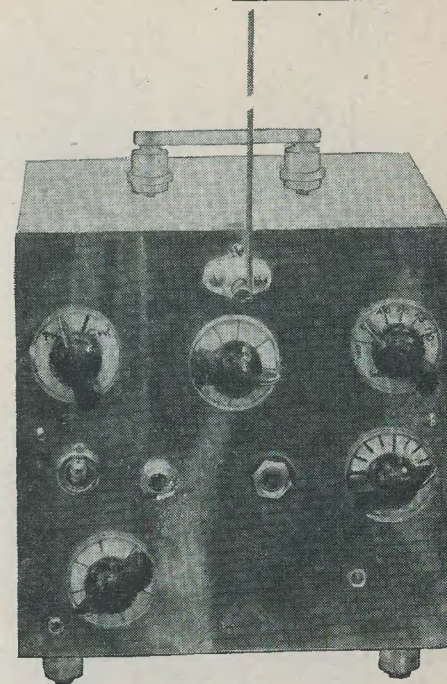
Nine authors have contributed to the ten chapters in this book, each of whom is a specialist in the subject he discusses. Mathematics have been kept to the barest possible minimum, but a fair amount of use is made of graphs and diagrams in some of the chapters.

The scope of the book covers subjective and objective judgment of performance, acoustics of sound reproduction, multiple channel systems, amplifiers and pre-amplifiers, dynamic and electrostatic loudspeakers, speaker enclosures, and tape, record and radio reproduction.

As is to be expected, when these separate subjects are dealt with individually, the standard of discussion is high and backed by authoritative knowledge. Consequently there is a great deal of learning and sound guidance available to the reader. If any one chapter can be singled out for special mention, it is perhaps that dealing with electrostatic loudspeakers in view of the recent development of this form of reproducer.

W. E. THOMPSON

AN ALL-BAND PHONE/C.W. SIGNAL MONITOR



A Useful Accessory for the Transmitting Station

By C. H. L. EDWARDS, G8TL

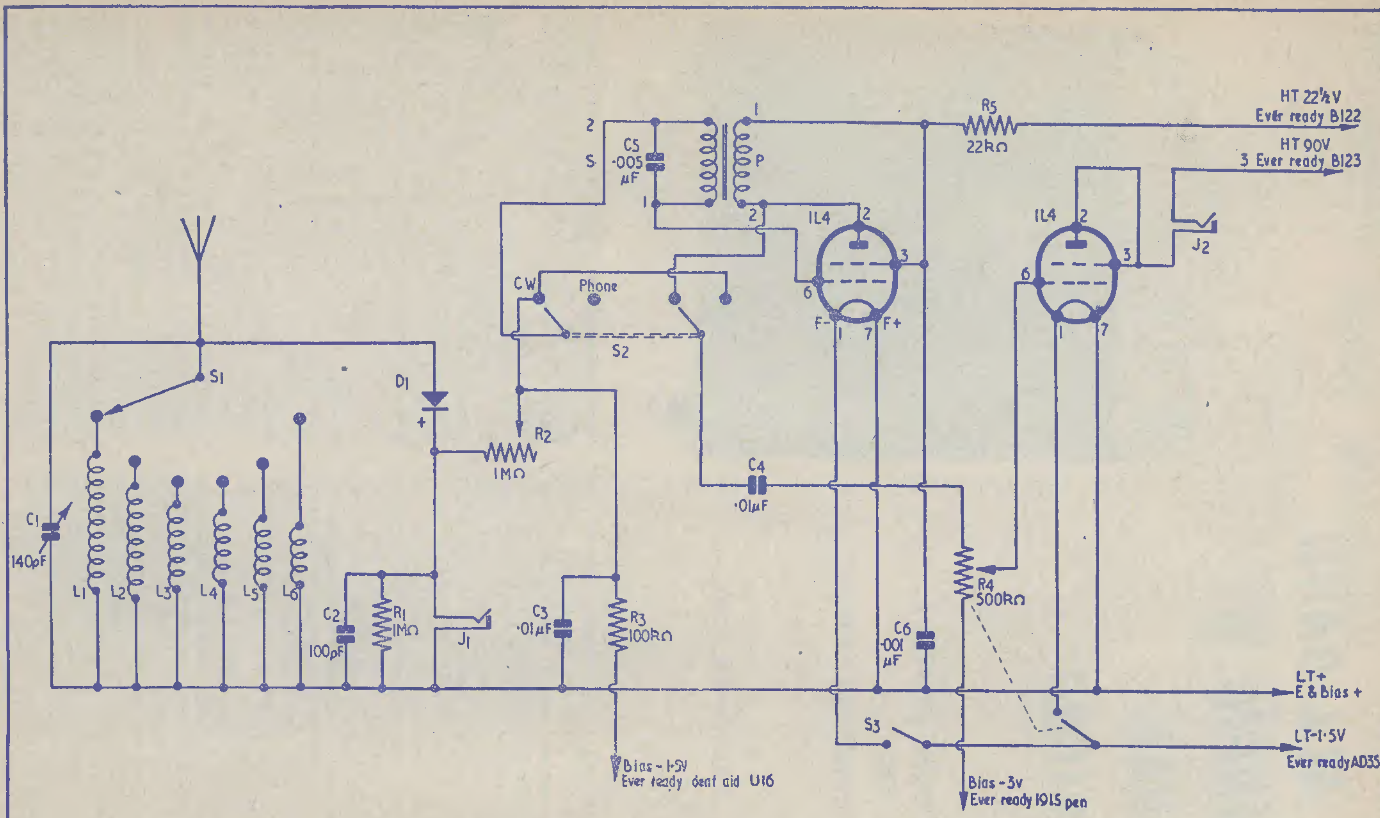
A PHONE AND C.W. MONITOR IS AN essential piece of equipment in all amateur stations. It is both simple and cheap to construct, and calls for no special or expensive components. The one described here was built around valves which the writer had in stock, and most of the components also were found in the " spares " box.

The phone monitor is fundamentally a simple crystal receiver, which will satisfactorily receive broadcast signals, provided suitable coils and an aerial are employed. If coils covering the amateur frequencies are placed into circuit, the monitor will pick up the transmitted signal in similar fashion, provided a short length of wire is connected to its aerial terminal.

In most cases the crystal monitor will be found to be quite satisfactory. If, however, it is desirable to have it completely portable, so that it can be moved around, or used in a car, a further stage of amplification may be necessary in order to achieve sufficient output. As can be seen from the circuit diagram, provision is made to switch in one of the 1L4 valves for this purpose. A knitting needle about 12in. long will suffice for pick-up and ample gain is obtainable—so much so that the signal can quite easily be monitored all over the house. If used close to the transmitter, the gain can be reduced by the potentiometer R_4.

To monitor c.w., a further valve (also a 1L4) is coupled into the circuit, and the 1MΩ potentiometer R_2 is adjusted so that it just does not oscillate. When the key of the transmitter is pressed, the signal picked up generates sufficient voltage to overcome the bias on the valve, and thus produces a note in the headphones, the pitch of which can be altered by adjusting the capacity C_5 across the secondary of the transformer. This monitors the spacing and quality of the sending, but not the actual tone of the transmitted signal itself. The miniature transformer from the dinghy lifeboat transmitter BX17/20/22743 is quite suitable for this circuit; a miniature 5:1 interstage transformer would also cope.

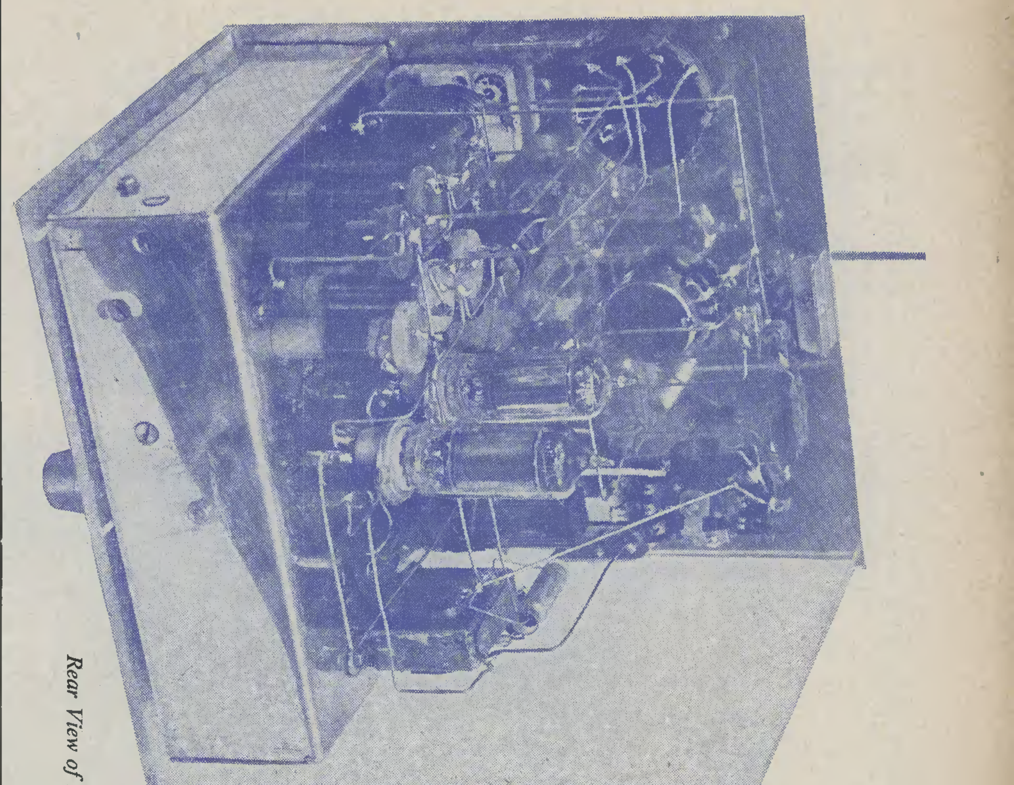
All coils are wound on Denco Miniature Maxi-Q formers; details of the number of turns and gauges of wire are given in the Components List. As will be seen from the photograph, the coils are mounted on the right-hand side of the chassis, and are coupled to a 6-way 1-pole wafer switch



All-band phone/signal monitor

List of Components Used in Prototype

R_1 1MΩ ¼ watt Dubilier resistor.
R_2 1MΩ Potentiometer, Dubilier.
R_3 100kΩ ¼ watt Dubilier resistor.
R_4 500kΩ Potentiometer and S.P. switch, Dubilier.
R_5 22kΩ ¼ watt Dubilier resistor.
C_1 140pF variable air spaced condenser, Eddystone.
C_2 100pF silver mica Dubilier condenser.
C_3 0.01μF 150V Dubilier condenser.
C_4 0.01μF 150V Dubilier condenser.
C_5 0.005μF 150V Dubilier condenser.
C_6 0.001μF 150V Dubilier condenser.
J_1 Open circuit Bulgin jack.
J_2 Closed circuit Bulgin jack.
1 Germanium crystal (D_1).
L_1 (160m) Maxi-Q Former, ⅞in. of close-wound 38 s.w.g. enamel wire, Denco (Clacton) Ltd.
L_2 (80m) Approx. ⅜in. of close-wound 38 s.w.g. enamel wire.
L_3 (40m) 50 turns 22 s.w.g. enamel wire.
L_4 (20m) 28 turns 22 s.w.g. enamel wire.
L_5 (15m) 17 turns 22 s.w.g. enamel wire.
L_6 (10m) 12 turns 22 s.w.g. enamel wire.
6 Miniature Maxi-Q formers, Denco (Clacton) Ltd.
1 6-way 1-pole wafer switch (S_1).
1 2-way 2-pole wafer switch (S_2).
2 1L4 Brimar valves.
1 Toggle switch S.P. (S_3).
1 Miniature dinghy transformer BX17-20/22743. (see text)
1 H.T. Ever Ready Battery 22½ volts B122.
3 H.T. Every Ready Batteries 30 volts B123.
1 L.T. Ever Ready Battery 1.5 volts AD 35.
1 L.T. Ever Ready Battery 1.5 volts U16 bias.
1 L.T. Ever Ready Battery 3 volts 1915 bias.
1 Front panel, aluminium, 6in. by 6in.
1 Chassis, aluminium, 5½in. by 4½in. by 1½in.



Rear View of Monitor

mounted on the rear of the front panel. The condenser C_1 is switched in turn across each coil and serves to tune in the required signal.

When only the crystal monitor is in use, the headphones are plugged into the phone jack J_1; the jack J_2 is used when the valves are in operation.

All batteries are carried under the chassis and are held in position by clips. As the current drain is low, they have a reasonably long life. The writer has only replaced them once in a period of over two years, the monitor having been in operation almost every day during this time.

It is advisable to couple a small indicator lamp across the filament circuit in order to remind the operator to switch off before leaving the shack. This lamp is not shown in the circuit. It has, however, proved its worth since being installed by more than once catching the eye of the writer in time to prevent him leaving the valves switched on for what otherwise would have been considerable periods.

Can Anyone Help?

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

J. Cheshire, 23 Broadway, Stanton Road, Shirley, Solihull, Warwicks, asks if any reader has any information on the R.C.A. D/F Receiver type CRV46123. A circuit diagram would be very helpful, and such data as the i.f., etc. Would be willing to purchase.

* * *

R. Calder, 17 Oakhill Road, Reigate, Surrey, wishes to obtain the circuit and constructional details of a battery operated tape recorder.

* * *

J. Wright, 23 Park Road, Redruth, Cornwall, has just acquired an R.107 communications receiver, and would like to hear from anyone who has built a converter for this set, or from where constructional data can be obtained.

* * *

M. A. Stewart, 6 Broadlands Road, Bromley, Kent, wishes to buy or to borrow the conversion data on converting the Radar Indicator Unit 233 to an oscilloscope.

* * *

A. Watts, The Royal School, Penn Road, Wolverhampton, Staffs, wishes to obtain on loan, or to purchase, a service sheet or data on a transmitter using two or more valves. He would like to employ the 12SC7 and 12A6 if possible.

* * *

A. Jameson, 75 Poplar Avenue, Pemberton, Wigan, Lancs, would like to purchase from any reader the circuit of the Pam transistor portable, or the circuit of the Cossor pocket radio.

* * *

E. Sedman, 4 Galtres Avenue, Stockton Lane, York, wishes to obtain any information, especially the circuit, on loan or otherwise, on the English Electric Electronic Ignition Tester model U.E.D.

W. Lowe, 28 Allenby Road, Cadishead, Manchester, is anxious to buy or to borrow the circuit of the H.M.V. model 494 receiver.

* * *

G. F. Riddell, 16 Firhill Street, Glasgow N.W., would like to obtain data for converting the R.A.F. 1145N transmitter for use on the amateur bands, and would be glad to hear from anyone who has worked this transmitter and to have details of the power pack and aerial systems used.

* * *

M. Buswell, 14 Bridge Street, Rothwell, Northants, would like to obtain the circuit of the Vortexion 4 or 3-channel microphone mixer units, and also the instruction manual and/or circuits for the Army type 19 Mk. 2 transmitter/receiver, plus any additional information which may be available. He is willing to purchase or to pay for the loan of any data.

* * *

B. Magrath, 36 Westcroft Road, Withington, Manchester 20, wishes to buy or borrow a service sheet and circuit for the Dynatron t.v. receiver "Fulmar" No. 27B.

* * *

C. Buckie, 10 Warwick Avenue, Staines, Middx., would be glad to obtain any information concerning the R.1116 receiver.

* * *

P. Bennett, 225 Camp Hill Road, Nuneaton, Warwicks, wishes to obtain the manual or circuit instructions for the Army No. 12 Transmitter.

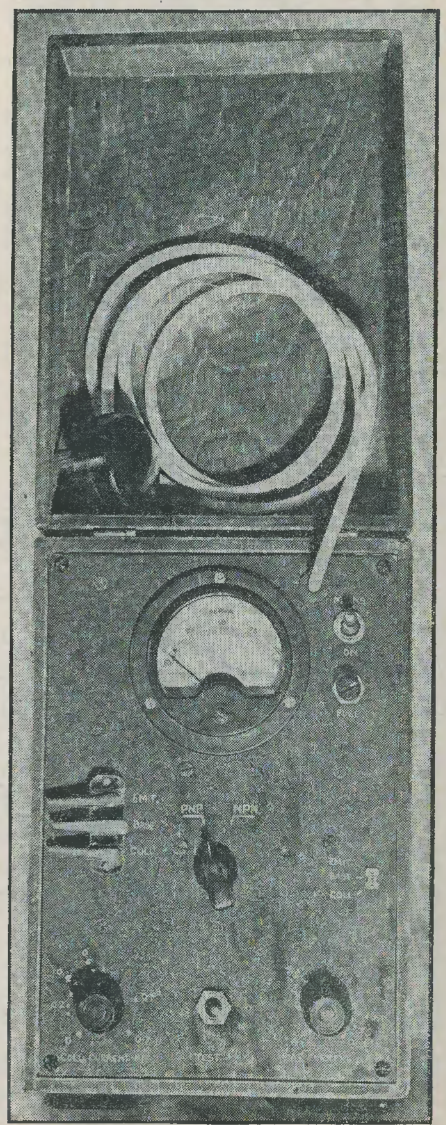
* * *

B. Chilvers, 45 Stafford Road, St. Helier, Jersey, wishes to obtain a copy of the March 1949 issue of *The Radio Constructor* containing an article on the conversion of the TR.1196 receiver. Can anyone help?

A Self-Calibrating
TRANSISTOR TESTER

Part 1

By **JOHN K. OWEN**



With the increasing employment of transistors, the provision of some means of testing them assumes ever increasing importance. In the present state of their development, such are the problems of manufacture that a normal specimen has a "spread" in its nominal rating of minus 40% to plus 70%. These figures apply to the regular output of "branded" types; it is probable that, in the case of the less expensive "surplus" varieties, the "spread" is even greater—there is at least no guarantee that this is not so!

Of the various parameters it is possible to test, the alpha, or current gain, is probably the most useful. Some indication of collector current is also desirable, particularly when matching transistors for push-pull.

Now, the obvious way to measure the current gain of a transistor is to set it up to the desired test conditions (collector voltage and initial emitter bias current) and, with a suitable meter in the collector circuit, read the increase of collector current when the bias current is increased by a known amount. If the respective bias currents are Ib_1 and Ib_2, and the corresponding collector currents Ic_1 and Ic_2, then the current gain is given by

$$\frac{Ic_2 - Ic_1}{Ib_2 - Ib_1}$$

If the increase in bias current is made some convenient figure, such as, for example, $10\mu A$, the mental arithmetic necessary to arrive at the correct answer is greatly simplified—since $10\mu A$ multiplied by 100 is equal to 1mA, it follows that every 1mA of collector current *increase* represents a gain of 100.

Fig. 1 shows the circuit in its simplest form. This is quite a practical arrangement which, while it suffers from two drawbacks—which will be referred to later—is still one to be considered as a temporary "lash-up," where the number of transistors to be tested is insufficient to warrant the provision of a complete instrument.

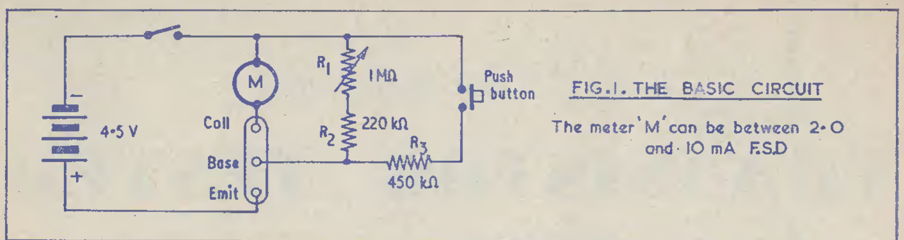


FIG. 1. THE BASIC CIRCUIT

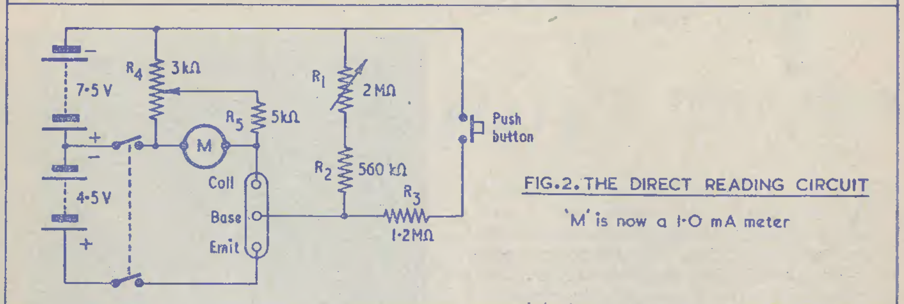


FIG. 2. THE DIRECT READING CIRCUIT

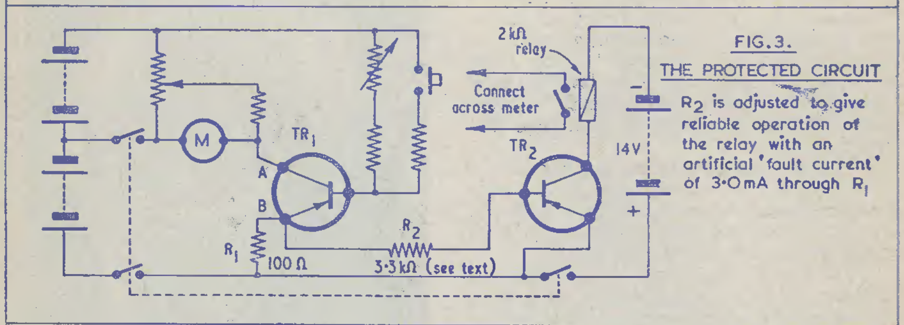


FIG. 3. THE PROTECTED CIRCUIT

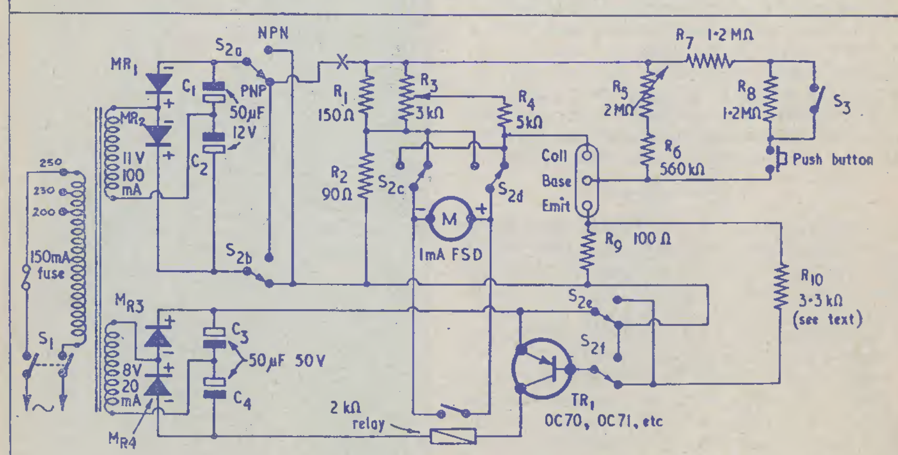


FIG. 4. THE COMPLETE CIRCUIT

All fixed resistors are ½ watt. Both variable resistors are carbon track

G 455

The meter M should preferably be 5mA F.S.D., but could be up to 10mA. R_1 and R_2 in series provide the initial bias, which, with the values shown, is variable from just under 4µA to approximately 20µA.

It is an advantage if R_1 is a linear, rather than a tapered, control; although this is not essential.

R_3 provides the 10µA increase in the bias current. The value quoted, 450kΩ, is the correct one for the 4.5V supply, and if means are available, it would certainly be worthwhile selecting one to within, say, 5% of this figure. However, if no means are available, a standard 470kΩ, 5% tolerance resistor, even in the least favourable disposition of the tolerance, would still be less than 10% in error, which, for this class of instrument, is reasonably satisfactory.

The transistor under test could be connected by miniature bull-dog clips, but steps would have to be taken to ensure that these could not short together.

Of the two drawbacks noted earlier, the first is the possibility, with a faulty transitor, of "bumping" (or even of permanently damaging) the meter. It will be seen that, should a "short-circuit" exist between the collector and the emitter, the meter would then be connected directly across the battery, with disastrous results. Unfortunately, a collector-to-emitter "short" appears to be a fairly common fault with junction transistors, so that the danger cannot be ignored.

With this circuit, therefore, it would be most advisable to test the transistor first with an ohmmeter, of not much more than 1mA F.S.D. The resistance between the emitter and collector leads should not be less than about 10kΩ with either polarity of the meter.

The second drawback is concerned with the accuracy of reading the meter. The circuit itself is capable of quite a high order of accuracy—the limiting factors being (i) the meter itself, (ii) the resistor R_3, and (iii) the voltage of the supply.

(i) This is likely to be the usual B.S. First Grade, with an accuracy of 2%.
(ii) The resistor can be selected to any desired degree of accuracy.
(iii) The supply voltage can, if necessary, be monitored.

The meter, however, has to be capable of carrying the standing collector current, and since it is only the relatively small change in current that we are interested in, the reading accuracy is not high.

To take an example, a particular transistor might have a standing collector current of 1.5mA, and an alpha of 30. This alpha would be represented by an increase of collector current, on operating the push-button, to 1.8mA, an increase of 0.3mA, which on a 5mA meter is inconveniently small.

This drawback is overcome by the circuit of Fig. 2. Here, the indicator is a 1mA meter, and the standing current is "backed-off" by the additional battery, in conjunction with R_4 and R_5. This is a very convenient arrangement, because now full-scale deflection represents an alpha of 100, so that all we have to do is to multiply the scale reading by 100.

In the example quoted above, for instance, an alpha of 30 is now represented by a deflection of nearly one-third full scale.

With a total battery voltage of 12V, as shown, the resistor R_3 becomes 1.2MΩ. This also is convenient, as it is a "preferred" value, and can be obtained to a tolerance of 5%.

It is possible to go a step further, and overcome the first drawback mentioned, namely, the danger to the meter arising from a faulty transistor. This is desirable if the tester is likely to be in regular use, as, sooner or later (human nature being what it is) the necessary precautions will be relaxed, and a faulty transistor will find its way into the tester. The consequent damage to the meter will depend on the extent of the leak between the collector and emitter, and the operator's speed in switching "off."

Now, a relay is very much swifter than the most vigilant of operators, and on this score alone merits inclusion. However, the operator who places an unchecked transistor in the tester is unlikely to be concentrating on the job in hand, which is where the relay really scores.

What is needed, then, is a relay which is operated by the fault current to short-circuit the meter. The normal current of a "good" transistor is unlikely to exceed 1.5mA (under the test conditions selected) so that, allowing a suitable margin for stability, we require the relay to operate at 2.5–3.0mA. With a standard (and therefore readily obtainable) relay, this would entail a coil resistance of around 5kΩ, which is, unfortunately, far too high to be included in the collector/emitter path. Even if the initial collector voltage was increased to allow for the drop across the relay, the further drop which would occur when the test button was depressed would make the meter indication meaningless.

The maximum allowable resistance is around 100Ω, so that the voltage across this will require some amplification to operate the relay. This amplification could, of course, be obtained by a valve, but is very much more efficiently provided by a transistor. An indirectly heated valve, of course, would be useless—by the time the cathode approached its operating temperature, the meter would be a smouldering ruin! Even with a directly heated (battery) valve, there is sufficient time-lag between the application of filament voltage and the rise of anode current to delay the operation of the relay a dangerous amount.

With a transistor, there is no such thermal delay, and (a further advantage) no necessity for the inconvenient filament supply.

Fig. 3 shows the protection circuit in its basic form. TR_1 is the transistor under test. The voltage actoss R_1 is applied between the base and emitter of TR_2, the control transistor, with R_2 limiting the bias current to the desired amount. The relay in the collector circuit is preferably a P.O. type 3000, with a coil resistance of 2 kΩ. The operating current for this particular relay is about 3mA (depending on the number of contacts it is carrying), but as this is a somewhat marginal condition, for positive operation it is preferable to increase the current to about 5mA. This gives a voltage drop across the coil of 10 volts, and, if we choose a collector supply of 4 volts, this is a total requirement of 14 volts. Assuming that we use a transistor of the OC71 type, from the characteristic curves a collector current of 5mA at a collector voltage of 4V, is given by a bias current of about 90μA. Now, we have already stipulated that the relay should operate when the fault current equals about 3mA. This fault current, then, develops 0.3 volts across R_1, so that the bias current of 90μA would require a series resistance R_2 of about 3.3kΩ. If, say, an OC70 is used (or one of the many surplus varieties) instead of the OC71, the value of R_2 would have to be reduced. The correct procedure would be to temporarily replace the 1 mA meter by a resistor of 1.5kΩ, and, using a variable resistor of around 5kΩ in place of R_2, short circuit the collector and emitter terminals—marked A and B on Fig. 3. This establishes the " fault " current at approximately 3mA. The relay contacts should be disconnected from the meter terminals.

R_2 should now be adjusted until the relay operates positively. Check that this is so by momentarily interupting and re-making the artificial " fault " current (by removing and replacing the " short " between A and B for instance) when the relay should snap in, without any preliminary " chatter."

The complete instrument, with the protection circuit, requires two separate supplies, one of 12 volts for the meter circuit itself, and one of about 14 volts for the protection circuit. While, due to the small current demands (and also the intermittent use to which it is likely to be subject) battery supplies are quite feasible, mains operation is both cheaper and more certain.

Fig. 4, then, shows the circuit in its final form. The apparently complicated switching is required only if it is intended to cater for both p.n.p. and n.p.n. type transistors.

Although, at the time of writing, practically all the available transistors are p.n.p., this is unlikely to remain the case for very long, and an instrument which only catered for the one type would be very limited.

The change-over from p.n.p. to n.p.n. is carried out by S_{2a-f}, a 6-pole 2-way switch. Sections a and b reverse the polarity of the supply, c and d reverse the meter, and e and f the emitter and base connections of the control transistor.

R_1 and R_2 form a potentiometer across the supply, the 4.5 volts for the collector being developed across R_2. The bleed current through the potentiometer is 50mA, this seemingly high value being required to maintain the necessary voltage regulation. The 4.5 volts is not critical but if the non-standard value of R_2 presents a difficulty, an alternative arrangement is to replace R_1 and R_2 by a 250Ω wire-wound potentiometer, setting the slider to 4.5 volts by means of a reasonably high-resistance voltmeter.

The mains transformer for the prototype model was provided by a 6.3V 2A heater transformer, with the secondary re-wound. This is not nearly such a tedious operation as it sounds, on account of the low voltages required. Since the transformer will only be running at something under 2 watts, almost any type will do—even quite a small output transformer, if space was really at a premium! However, the usual heater type takes up very little room, and makes the re-winding much easier. The odd voltages are required to allow for drop across the rectifiers, both of which are arranged as voltage doublers. MR_1 and MR_2 might occasion some difficulty. Obviously, the small germanium or silicon " signal " diodes will not handle the 50mA. Some of the new junction diodes would, but they are not easy to obtain.

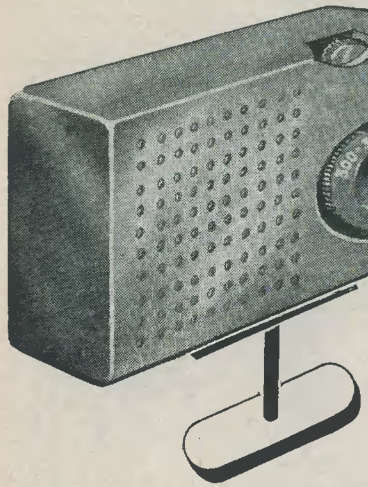
The solution adopted in the original model was the stripping and re-building of a selenium " stack."

As purchased, this was a 150 volt 60mA type and, since it contained 12 units, this meant that each one would handle about 13 volts, so that only one unit was required for each of MR_1 and MR_2.

The rectifiers MR_3 and MR_4, for the protection circuit, have to handle a maximum of some 10mA, so that the small germanium " point-contact " is ample here.

The backing-off control R_3 can either be calibrated in mA of collector current, or may simply be provided with a uniformly divided scale. It will then serve as an indication of collector current—a useful feature when matching transistors for push-pull. The bias control can also be calibrated (in μA) though here again this is a refinement which is not essential.

(*To be concluded*)



The MINI-7 TRANSISTOR SUPERHET POCKET PORTABLE

This article gives preliminary constructional details of a 7-transistor portable superhet intended for the more advanced constructor, which can truly be carried in a pocket or in a handbag. The Mini-7 offers an excellent performance with its own slab ferrite aerial, providing a volume level which is more than ample. It is housed in an attractive plastic cabinet of contemporary design.

Part 1

Described by **D. PETERS**

Transistorised receivers have, for some years, been very popular amongst home constructors. The reason for this popularity is not hard to find when the advantages which are conferred by the use of transistor circuitry are fully examined. There is first of all the fact that transistors represent a new and intriguing breakaway from the conventional valve circuits with which most constructors are already very familiar. The radio amateur has always been prepared to take on something fresh and, much more often than not, make a complete success of it. Secondly, transistor circuitry lends itself especially well to the manufacture of miniaturised receivers; with the result that a considerable amount of satisfaction may be obtained from the fascinating process of making equipment which, despite very small and compact dimensions, still offers a performance commensurate with that of bulkier equivalents. Thirdly, due to the availability of suitable transistors through the normal home constructor trade channels, the making up of transistor equipment does not incur excessive costs.

The Mini-7, the receiver which forms the subject of this and a succeeding article, exploits to the full all the advantages given by the use of transistors. The receiver is a 7-transistor superhet having class B push-pull output, two i.f. amplifier stages, and its own internal ferrite slab aerial; and it is designed to tune over the medium wave band. If desired, it is possible to carry out a simple modification which enables a long wave station to be received as well. This latter point will be of particular interest to those constructors who reside in areas where reception of the medium wave Light Programme transmitter is difficult.

An idea of the small size of the Mini-7 may be obtained from the photographs of the chassis which accompany this article. An excellent impression of the set's compactness is given by the fact that the loudspeaker, visible in the photograph of the front, is a Rola $2\frac{1}{2}$ inch model. As will be observed,

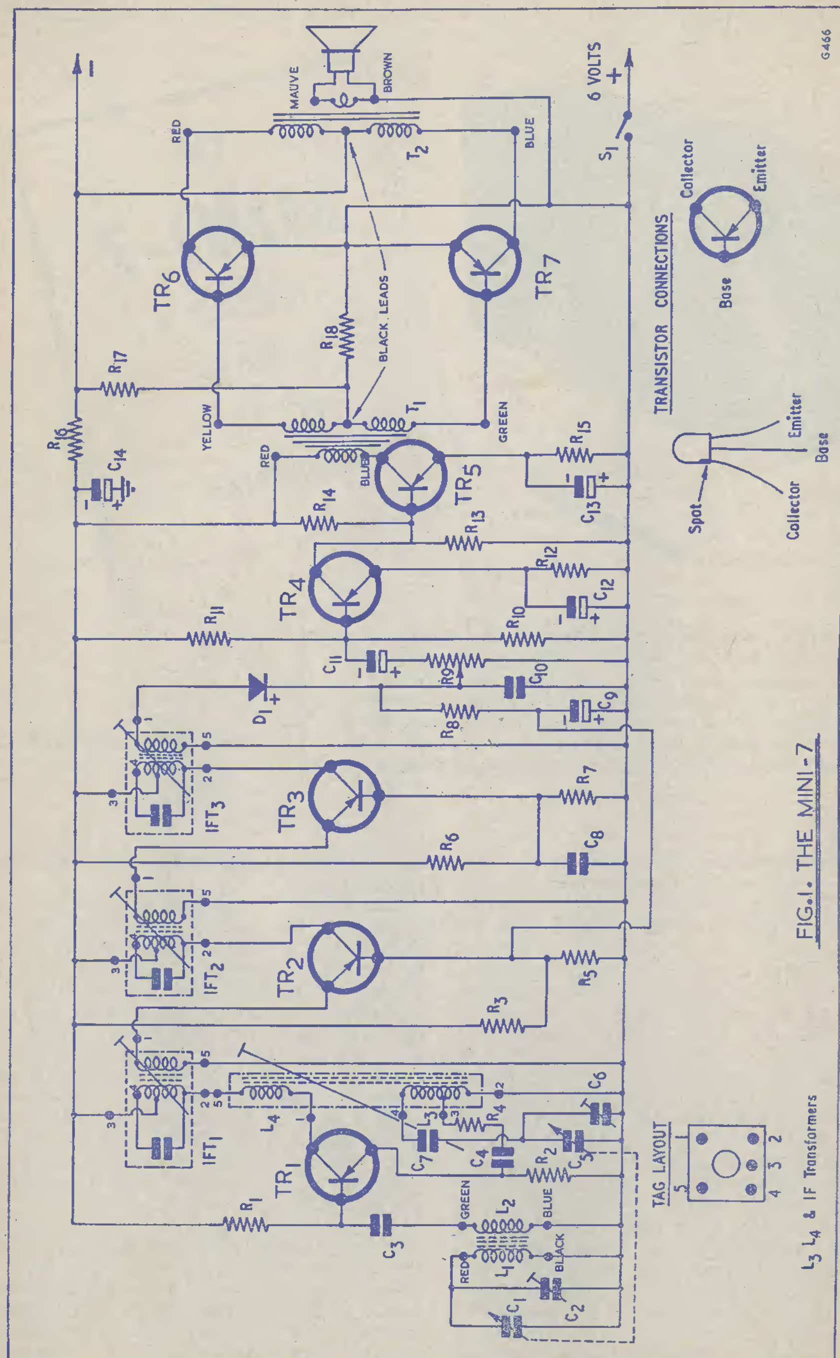


Fig. 1. The theoretical circuit of the Mini-7

this speaker takes up nearly half the frontal area of the chassis. The depth of the chassis, incidentally, is only slightly greater than that of this loudspeaker. A feature which particularly lends itself to compactness is the use of the Jackson Bros. twin-gang tuning condenser type "00." Although providing full coverage of the medium wave band the depth of this tuning condenser, below the chassis, is of the order of one inch only.

A large quantity of the components employed in the design, including the insulated component board which forms the basis of the chassis, and the cabinet and matching knobs, are available from Repanco Ltd., and through them from other advertisers.

The knobs are finished in scarlet, whilst the cabinet, whose dimensions are 5⅛ in by 3⅛ in by 1⅝ in only, is dove grey.

The Circuit

The circuit of the Mini-7 is reproduced in Fig. 1, and it would be of advantage to consider this in some detail before passing on to the construction.

As was mentioned above, the receiver employs its own slab ferrite aerial, and this is shown in Fig. 1 as L_1, L_2. Both L_1 and

Components List

Resistors

Apart from R_9, all resistors should be Dubilier ¼ watt type BTS, or have the same physical size.

- R_1 330kΩ
- R_2 10kΩ
- R_3 82kΩ
- R_4 300Ω (see note)
- R_5 4.7kΩ
- R_6 220kΩ
- R_7 47kΩ
- R_8 3.3kΩ
- R_9 10kΩ miniature potentiometer with switch (Radiospares)
- R_{10} 10kΩ
- R_{11} 47kΩ
- R_{12} 1kΩ
- R_{13} 10kΩ
- R_{14} 3.3kΩ
- R_{15} 1kΩ
- R_{16} 56Ω
- R_{17} 6.8kΩ
- R_{18} 150Ω

Note.—The value given for R_4 is average.

Condensers

- C_1, C_5 Two-gang condenser type "00" (Jackson Bros.)
- C_2, C_6 2 × 60pF trimmer block (Repanco)
- C_3, C_4 0.01μF, 150V wkg type W99 (Hunts)
- C_7 300pF±5% miniature, silver mica or polystyrene
- C_8 0.1μF 150V wkg, type W48 (Hunts)
- C_9 8μF electrolytic type CE67B (T.C.C.) or type AC5705-8 (Mullard)
- C_{10} 0.01μF 150V wkg, type W99 (Hunts)
- C_{11}, C_{12}, C_{13} 8μF electrolytic type CE67B (T.C.C.) or AC5705-8 (Mullard)
- C_{14} 100μF 6V wkg, electrolytic type CE59AE (T.C.C.)

Coils and Transformers

- L_1, L_2 Ferrite slab aerial type FS3 (Repanco)
- L_3, L_4 Oscillator coil type XO8 (Repanco)
- IFT_1, IFT_2 Miniature i.f. transformer type XT6 (Repanco)
- IFT_3 Miniature i.f. transformer type XT7 (Repanco)
- T_1 Miniature interstage transformer type TT9 (Repanco)
- T_2 Miniature push-pull output transformer type TT10 (Repanco)

Transistors and Diode

- TR_1 OC45 (Mullard) or equivalent
- TR_2, TR_3 R.F. transistor "white spot"
- TR_4, TR_5, TR_6, TR_7 L.F. transistor "red spot"
- D_1 OA70 (Mullard) or equivalent

Loudspeaker

2½in, type C25 (Rola)

Chassis

Group board type 17/S and battery clips (Repanco)

Batteries

2 transistor batteries, type V.0038, 3 volt (Vidor) or type D22 (Ever-Ready)

Cabinet and Knobs

Dove-grey plastic cabinet (Repanco)
Scarlet control knobs (Repanco)

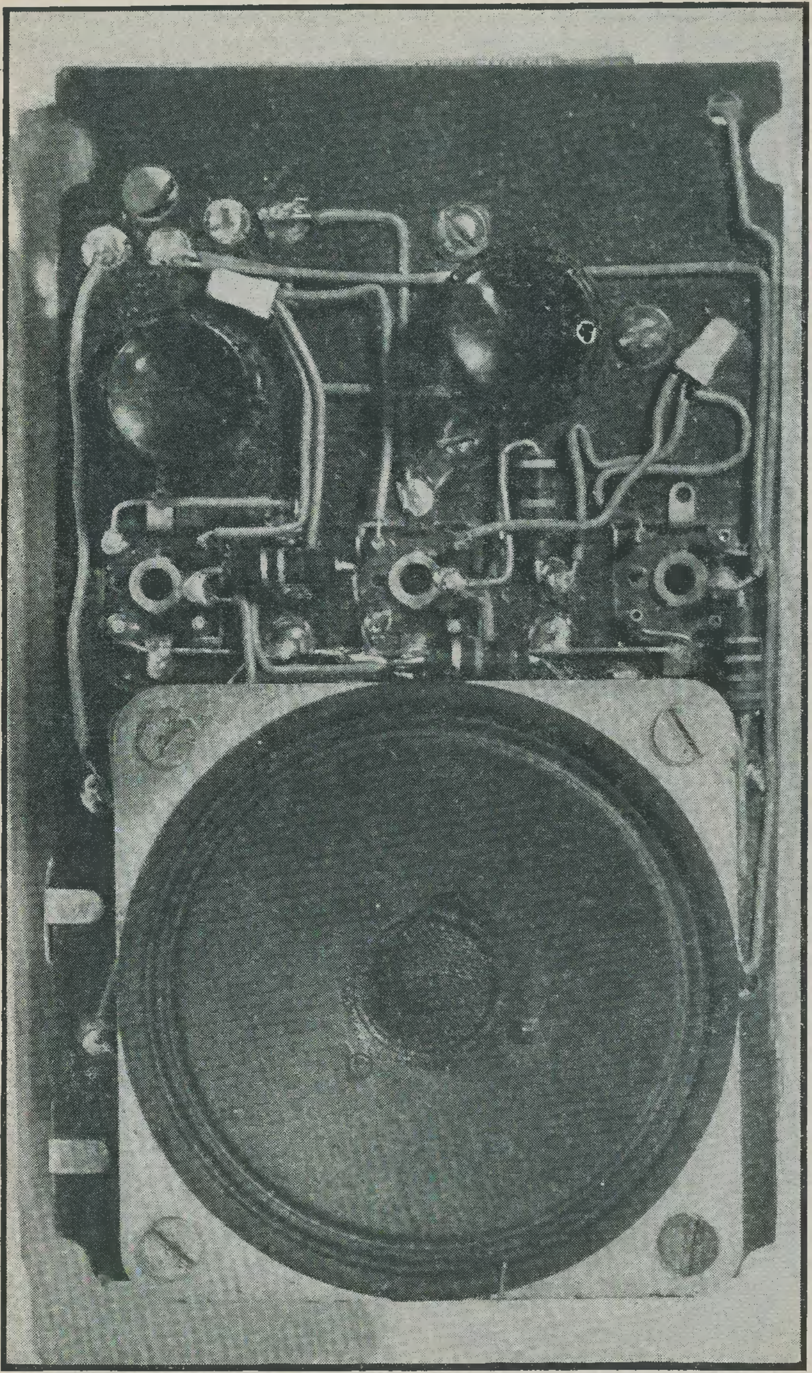
Miscellaneous

- 3 4BA × ⅛in R.H. or C.H. screws
- 7 4BA × ⅛in C.S. screws
- 1 4BA × ¼in C.S. screw
- 3 8BA × ⅛in R.H. or C.H. screws
- 2 4BA washers
- 4 4BA solder tags
- 2 8BA solder tags
- 3 8BA fullnuts
- 4 11/32in × ¼in pillars, tapped 4BA (Repanco)
- 1 yd 1mm p.v.c. sleeving
- 1 yd 20 s.w.g. tinned copper wire
- ½ yd single strand red p.v.c. covered wire
- ½ yd single strand green p.v.c. covered wire

Modification Kit

These components are required *only* if it is desired to carry out the modification for long wave reception.

- 1 Long wave loading coil type XL1 (Repanco)
- 1 wave change switch s.p.d.t. miniature
- 1 250pF condenser, silver mica or polystyrene



Top-of-Chassis Layout—See Fig. 2

L_2 are mounted on the ferrite slab. The winding L_1 is that which is tuned, L_2 providing the necessary low impedance coupling for the frequency changer TR_1. The windings L_1 and L_2 are fitted to the ferrite slab such that they may be moved along it, thereby enabling an adjustment of tuning inductance to be obtained.

The transistor TR_1 functions as a frequency changer in a conventional circuit, the coil L_3, L_4 providing the oscillator tuned coil and feedback winding respectively. The resistor R_4 limits oscillator amplitude and an average value, 300Ω, which should cope adequately with most transistors, is specified. If it is found that oscillation is excessive, resulting in spurious responses, the value of R_4 should be increased. Similarly, if oscillation amplitude appears low R_4 may be reduced in value. The condenser C_7, in series with tuning condenser C_5, is a padding component and assists in ensuring that good tracking is obtained.

The collector of TR_1 feeds, via L_4, into the first i.f. transformer and, thence, into the i.f. stages. I.F. amplification is provided by TR_2 and TR_3, both of which function in the earthed base mode. A point worthy of note is that the intermediate frequency employed in the Mini-7 is 465 kc/s, and not one of the lower frequencies commonly encountered in transistorised i.f. amplifiers.

The three i.f. transformers all consist of single tuned circuits with coupling windings, these being designed to give optimum performance at the low impedances which occur in transistor applications. The secondary of IFT_3 is intended to feed into the diode detector circuit. The diode D_1 also provides an a.g.c. voltage, this being applied back, via the decoupling components R_8 and C_9, to the base of TR_2.

The detected a.f. signal is next fed, via C_{11}, to the first a.f. amplifier TR_4, this being connected in an earthed emitter circuit. TR_4 is followed by TR_5, which also operates as an earthed emitter amplifier. The amplified signal from TR_5 is then applied to the two class B output transistors, TR_6 and TR_7, which in their turn drive the loudspeaker.

As may be seen, the circuit of the Mini-7 provides a high degree of amplification, both at i.f. and at a.f. This high degree of amplification not only ensures that there is "plenty in reserve" so far as aerial sensitivity is concerned, but also that any signal which is received can be reproduced from the loudspeaker at a very satisfactory volume level.

Before completing this discussion on the circuit it is worth noting that the power requirements of the Mini-7 are very modest as far as voltage is concerned. The whole receiver is powered by a 6 volt supply, this being provided by two series-connected 3 volt batteries which are intended especially for transistor work.

Construction

Construction of the Mini-7 is a relatively simple operation owing to the availability of the circuit board, this being already punched and fitted with eyelets for soldered connections. Due to the extreme compactness of the receiver some care should be observed during assembly in order to prevent damage to miniaturised components and transistors. A small instrument type soldering iron is recommended, and this should be used with a good quality cored solder.

To ensure that assembly proceeds logically and reliably, the constructor is strongly advised to follow the step-by-step instructions which follow in this and the succeeding article. It will be noted, in the various assembly diagrams, that holes in the component boards are designated with letter references, whilst eyelets are numbered. The positions of both holes and eyelets are readily ascertainable from the diagrams. This month, two of the main assembly diagrams, Figs. 2 and 3, are published. However, most of the constructional detail in this particular article centres around Fig. 2, only occasional reference being made to Fig. 3. In next month's article it will be necessary to make rather more detailed reference to Fig. 3, with the consequence that this issue of *The Radio Constructor* should be carefully retained.

First Steps

The first component to be mounted to the insulated circuit board is the volume control (and switch) R_9. It is possible that the volume control may be obtained with too long a spindle, in which event this should be cut to $\frac{5}{32}$in, as measured from its circlip; see Fig. 4. The control is supplied with two bush nuts, one of which would normally be employed as a locking nut. To ensure that the spindle does not project too far forward when the control is fitted to the Mini-7 board, these two nuts are fitted to the bush on either side of the board. The nuts should be adjusted such that the switch moulding projects one inch below the circuit board, as shown in Fig. 5. The volume control is fitted to hole D (Fig 2) such that its spindle projects upwards. The tags of the volume control should project inwards, as illustrated in the below-chassis view given in Fig. 3.

The next component to be fitted is the two-gang condenser C_1, C_5. Here again, it may be necessary to reduce spindle length. The spindle of the condenser should project $\frac{5}{16}$in from the front of the condenser frame. Fig. 6 illustrates this dimension.

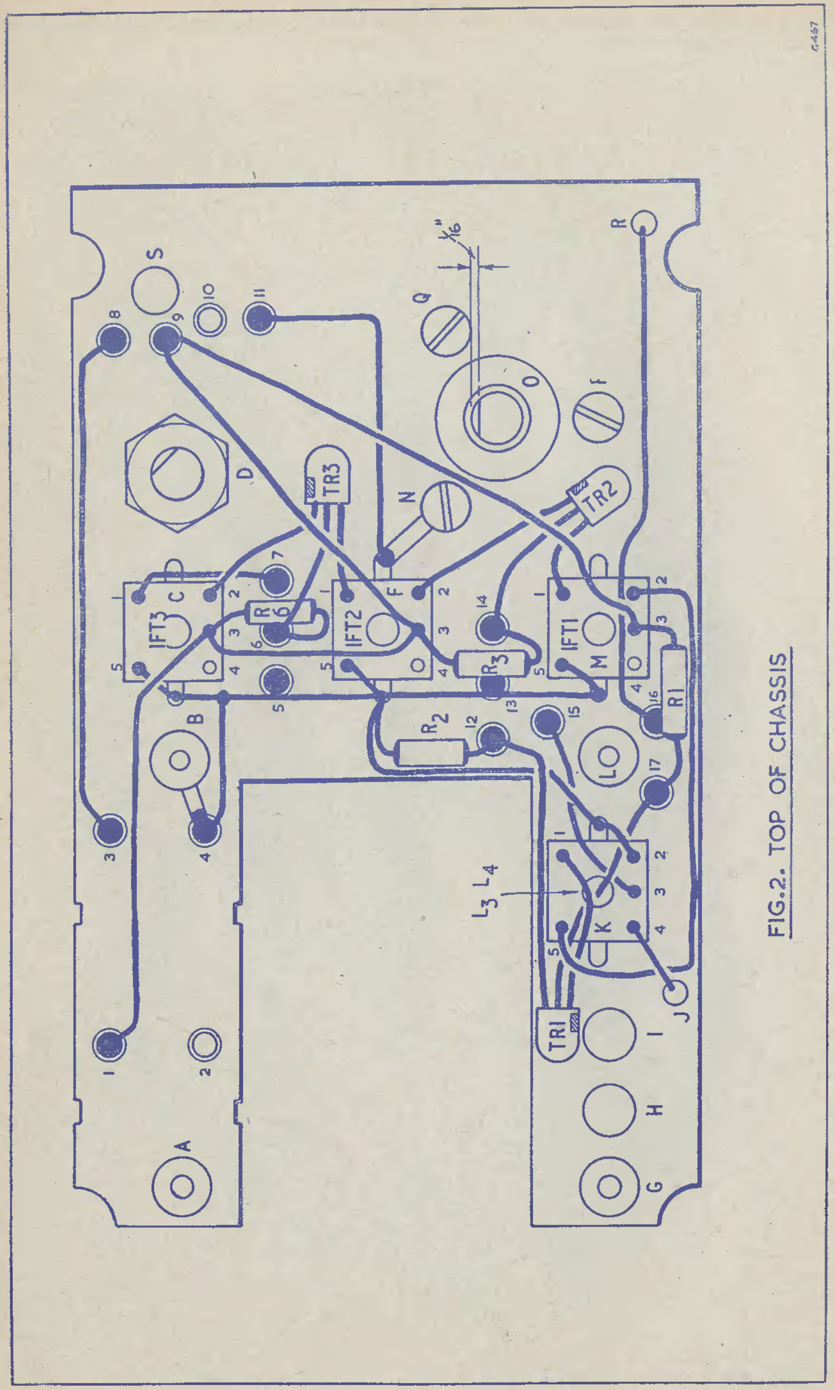


Fig. 2. First steps in assembly. This diagram shows the top of the component board

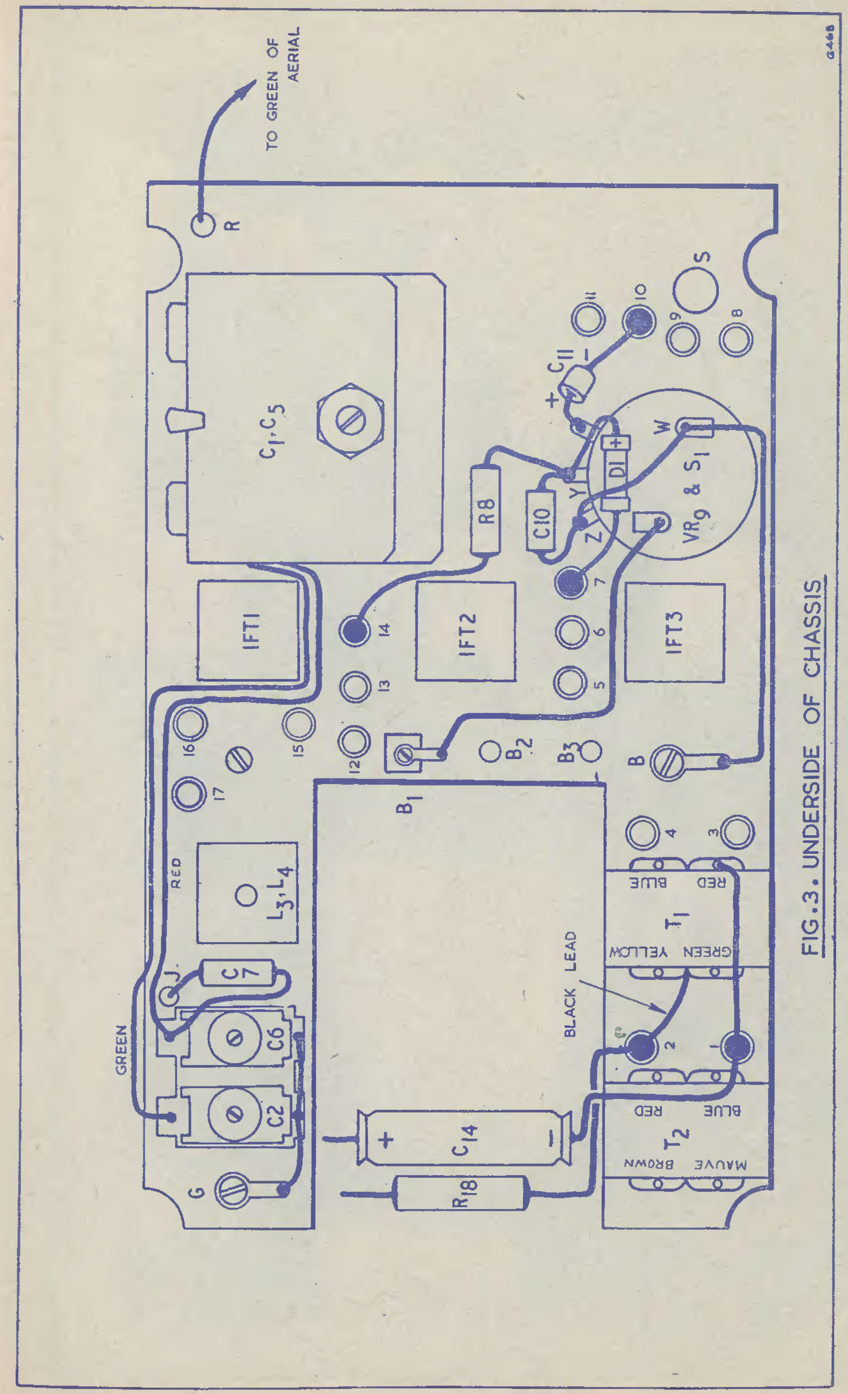
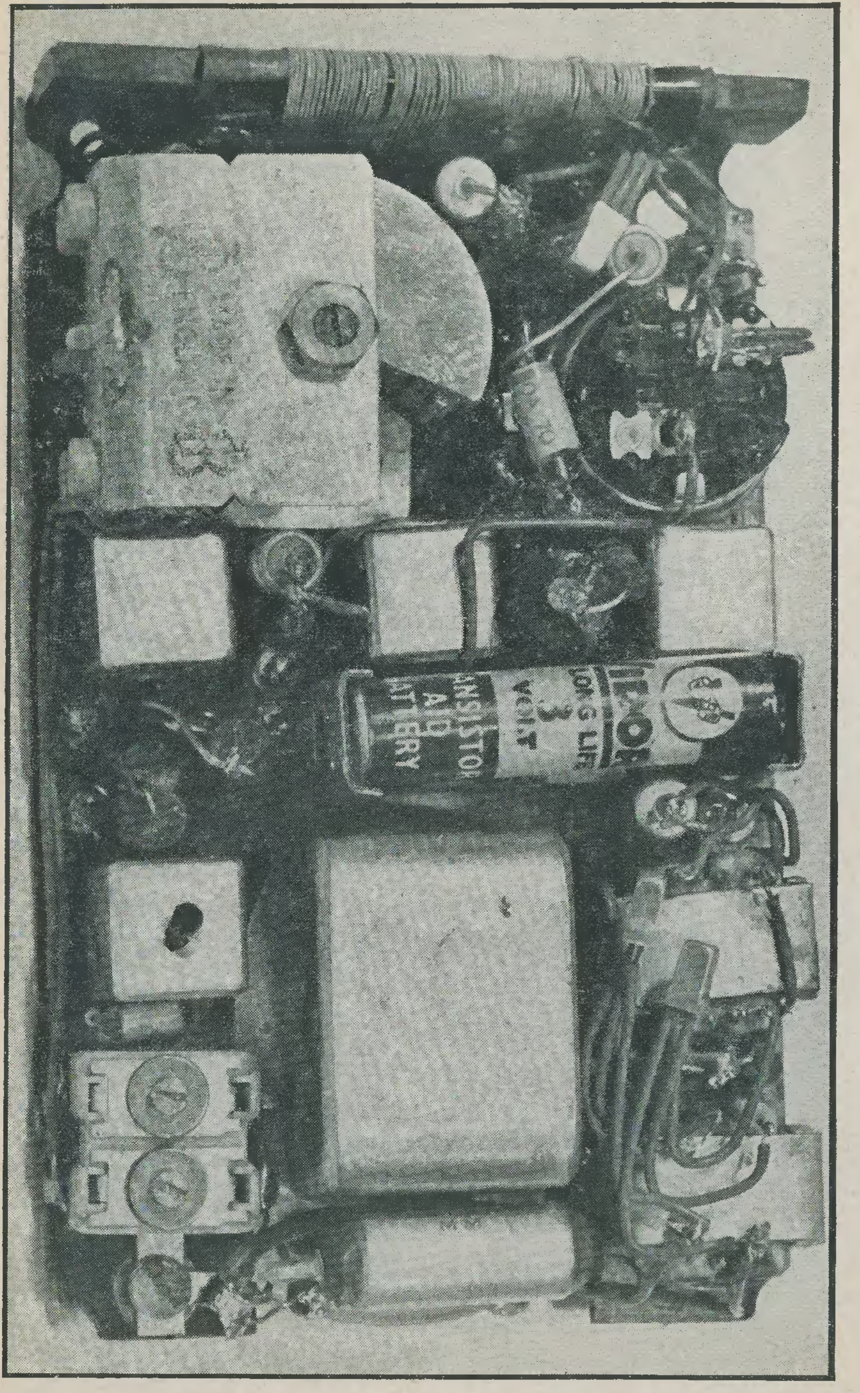


Fig. 3. Bottom view of the component board, illustrating also a later stage in wiring



Underneath-of-Chassis Layout—See Fig. 3

Two leads have to be soldered to the tags of the tuning condenser before it is mounted on the component board. A 4in length of *green* p.v.c. covered wire is first soldered to the right-hand tag of C_1, the front section; and a second 4in length of *red* p.v.c. covered wire is soldered to the right-hand tag of C_5, the rear section. The "right-hand" side may be identified by holding the condenser spindle uppermost and viewing from the rear.

The two-gang condenser is fitted to the circuit board such that it takes up the position shown in Figs. 2 and 3. The spindle of the condenser projects through hole O to the top of the board and it is secured with three 4BA × $\frac{1}{8}$in roundhead or cheesehead screws. Screws longer than $\frac{1}{8}$in should *on no account* be used, as these may foul and damage the vanes. The three screws are fitted through holes N, P and Q, that at hole N having a 4BA solder tag under its head (see Fig. 2). It may be necessary to file a flat on the tuning condenser spindle, in which case this operation should be carried out before construction proceeds. The flat is parallel to the edge of the board when the condenser vanes are fully enmeshed, and it should have a depth of $\frac{1}{16}$in. Fig. 2 illustrates the position of this flat. Before carrying on to the next step in assembly, the four solder tags of the condenser should be gently pushed upward so that they do not protrude outside the condenser frame. To obviate the risk of accidental damage, it is advisable to keep the condenser vanes fully enmeshed until construction has been completed.

The loudspeaker mounting pillars come next. These pillars carry out the function of spacing washers and consist of cylinders which are $\frac{11}{32}$in long and whose central holes are tapped 4BA. It then becomes possible for 4BA screws to be inserted into them from either end. The four pillars appear on the top side of the board (i.e. on the same side as the volume control and tuning condenser spindles) and they are held by screws passing through holes A, B, L and G. The screws at A, B and L are 4BA × $\frac{1}{8}$in countersunk, whilst that at G is 4BA × $\frac{1}{4}$in countersunk. The screw at G need not be finally tightened at this stage as it will be employed, later, to hold the trimmer block below the chassis. The screw at B secures also two 4BA solder tags, one below the chassis (Fig. 3) and one above the chassis and under the pillar (Fig. 2). The orientation of these two tags, as shown in the diagrams, should be carefully observed.

The third i.f. transformer (IFT_3) is fitted next, and its position is illustrated in both Figs. 2 and 3. The can of the transformer appears on the underside of the chassis. The tags of IFT_3 should take up the position illustrated in Fig. 2, and its can is secured in place by bending its bottom lugs outwards. The second i.f. transformer (IFT_2) follows, and this is mounted in place in the same manner, its tags taking up the positions shown in Fig. 2. The first i.f. transformer is also mounted at this stage, care being taken once more to ensure that the tags appear as shown in Fig. 2. In the case of IFT_1 it is advisable to ascertain that the tags of the tuning condenser do not touch the can.

The oscillator coil L_3, L_4 comes next, and its can is made secure to the board in the same manner as were those of the three i.f. transformers.

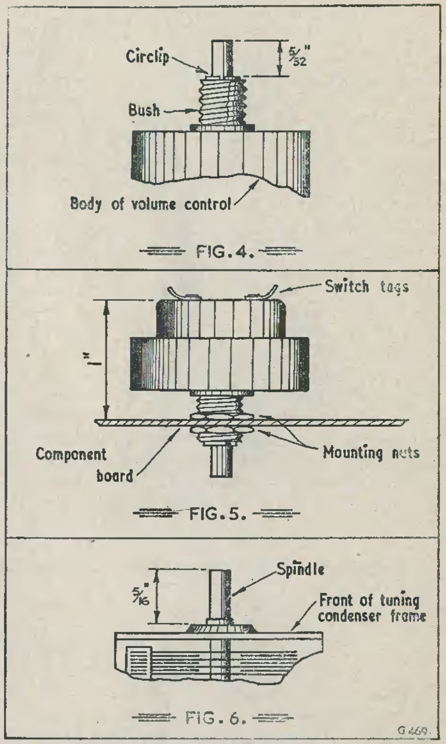


Fig. 4. The spindle of the volume control should have the dimension illustrated here. Fig. 5. How the volume control is fitted to the component board. Fig. 6. The correct length for the tuning condenser spindle.

Wiring Up

Wiring of the receiver may now commence. Unless otherwise stated, all wiring and components should be kept close to the board.

Using bare tinned copper wire, solder together the bent-over lugs of the three i.f. cans on the side nearer the loudspeaker cut-out. A straight piece of wire is required for this operation and it will be found that it passes directly over eyelets 5 and 13 (Fig. 2). The wire is soldered to these two eyelets.

Next connect a piece of bare tinned copper wire between the wire just soldered in and eyelet 4 (Fig. 2). The solder tag fitted under the loudspeaker pillar at B lies directly over eyelet 4; and this is also soldered to that eyelet. Also connect a piece of bare tinned copper wire between the can lug of IFT_2 and that of L_3, L_4.

Using bare tinned copper wire the following connections are made, referring all the time to Fig. 2. Connect tag 5 of IFT_3 to its adjacent can lug, tag 5 of IFT_2 to its adjacent can lug, tag 5 of IFT_1 to its adjacent can lug, and tag 2 of L_3, L_4 to its adjacent can lug. Connect the solder tag under the tuning condenser mounting screw at hole N to the adjacent can lug of IFT_2 and join this point to eyelet 11 with *p.v.c. covered* wire. Solder the p.v.c. covered wire at eyelet 11.

The following connections require p.v.c. covered wire and *not* bare tinned copper, and Fig. 2 illustrates the route which each lead should take as it is soldered in. Connect eyelet 3 to eyelet 8. Connect eyelet 1 to tag 3 of IFT_3. Connect tag 1 of IFT_3 to eyelet 7. Connect tag 3 of IFT_3 to tag 3 of IFT_2. Connect tag 3 of IFT_2 to eyelet 9.

Some further components may now be fitted. The first of these is R_6 (220kΩ), this being connected, as shown in Fig. 2, between tag 3 of IFT_3 and eyelet 6. Next connect R_3 (82kΩ) between tag 3 of IFT_2 and eyelet 14, as shown in Fig. 2. Finally connect R_2 (10 kΩ) between eyelet 12 and the adjacent can lug of IFT_2, again checking against Fig. 2.

Next connect one end of a 4in length of p.v.c. covered wire to eyelet 16, passing the other end through hole R. The free end is connected at a later stage.

This step is followed by connecting together, with p.v.c. covered wire, tag 2 of IFT_1 and tag 5 of L_3, L_4. Next, fit R_1 (330 kΩ) between tag 3 of IFT_1 and eyelet 17. Using p.v.c. covered wire, connect tag 3 of IFT_1 to eyelet 9. Fitting sleeving over the lead-out wires, connect the collector of transistor TR_1 to tag 1 of L_3, L_4; the base of TR_1 to eyelet 17; and the emitter of TR_1 to eyelet 12. Ensure that this transistor takes up the position shown in Fig. 2 and that it lies close to the chassis. Using p.v.c. covered wire connect tag 3 of L_3, L_4 to eyelet 15. Fitting sleeving over its lead-out wires, connect the collector of transistor TR_2 to tag 2 of IFT_2; the base of TR_2 to eyelet 14; and the emitter of TR_2 to tag 1 of IFT_1. As with TR_1, this transistor should take up the position shown in Fig. 2, and should lie close to the chassis.

Similarly employing sleeving on its lead-out wires and following the layout of Fig. 2, finally wire up transistor TR_3 in the following manner. Connect the collector of TR_3 to tag 2 of IFT_3; the base of TR_3 to eyelet 6; and the emitter of TR_3 to tag 1 of IFT_2.

Next Month

In next month's issue we shall complete the assembly instructions for the Mini-7. Alignment details will also be given, as will a description of the modification needed for long wave reception.

TRADE ITEMS

ARDENTE ACOUSTIC LABORATORIES LTD., are pleased to announce that Sam Mozer Ltd., 288 Hedge Lane, London, N.13, has been appointed distributor for Ardente Miniature Electronic Components. Enquiries from manufacturers should continue to be addressed direct to Ardente Acoustic Laboratories Ltd., 8/12 Minerva Road, London, N.W.10.

CLAUDE LYONS LTD., Valley Works, 4-10 Ware Road, Hoddesdon, Herts, have issued a new publication entitled "Consolidated Net Price List and Buying Guide," Form BG-58. This publication gives in compact and handy form brief technical details and net trade prices for the very great majority of their products.

NEWMARKET TRANSISTOR CO. LTD., the manufacturers of the GOLTOP range of transistors, announce reductions of up to 25% in the price of their R.F. and Power Transistors. Exning Road, Newmarket, Suffolk. *Telephone* Newmarket 3381.

Which Tape Should I Use?

By A. BARTLET STILL

RECIPE

Ingredients

Take:

6 oz of suitable transparent plastic

¼ oz plain magnetic oxide Fe2O3 or Fe3O4 (must not be self-erasing)

¼ oz bonding lacquer

Method

Mix the oxide and lacquer into a smooth paste taking care to avoid the formation of lumps and put on one side.

Roll out the plastic to a strip of even thickness 1,200ft long and ¼in wide.

Apply the prepared mixture to one side of the plastic strip and pass through a cooling oven until the lacquer is set.

Serve wound on a suitable spool 7in dia. and garnish with gaily coloured leader tape.

SOME READERS MAY FIND, HOWEVER, THAT the manufacture of magnetic recording tape is not quite so easy as the above would imply, and they are recommended to purchase their tape ready for use from one of the well-known makers.

There can hardly be a single tape recorder owner who has not asked, at some time or another, "Do different brands of tape vary, and is there one, more than any other, that is better for my machine?" In the writer's opinion, the answer to both these questions is a most definite affirmative, and it will be the purpose of this article to discuss the differences that exist, and investigate their effect on the ultimate performance. Whatever the reasons may be that cause a commercial tape recorder manufacturer to recommend a particular brand of tape, there can be no doubt that once adjusted for that tape, it may give inferior results on any other.

It would be as well to make it clear at this point that, in the writer's opinion again, there is little to choose between the various brands, provided they are recorded under their own optimum conditions.

There are, of course, certain physical differences; one may be more brittle, another stretch more easily, a third may, perhaps, have a more abrasive surface, causing greater head wear, but the electrical differences are generally not as great as can be produced by incorrect conditions.

Electrical performances of tape will here be considered by three parameters: sensitivity, output for a given distortion, and frequency response. The one factor that affects all these parameters simultaneously is the recording bias and, in consequence, it is proposed to investigate the effects of bias variations in some detail.

One sample of tape is to be considered; the story would be much the same with any other. The machine on which the tests were made was adjusted firstly to have a CCIR playback response using an E.M.I. Test Tape TBT 1. With "optimum" bias for the tape in question, the recording amplifier was set to give a flat overall frequency response. From then on the only changes made were to the bias applied to the recording head, and to the signal applied to the recording amplifier. At this point "optimum" bias is determined in a conventional manner; further tests will show whether or not it is all that the name implies. Measurements are taken, therefore, from which the curves in Fig. 1 are plotted. The level of 10 db below "Full Mod." is, of course, only an arbitrary one, since full modulation level may well vary with bias. It is intended to ensure that there are no false readings due to saturation. The distortion curve is of academic interest only, but serves to illustrate the advisability of choosing a bias point at the peak or beyond.

Conventionally, then, the bias setting that

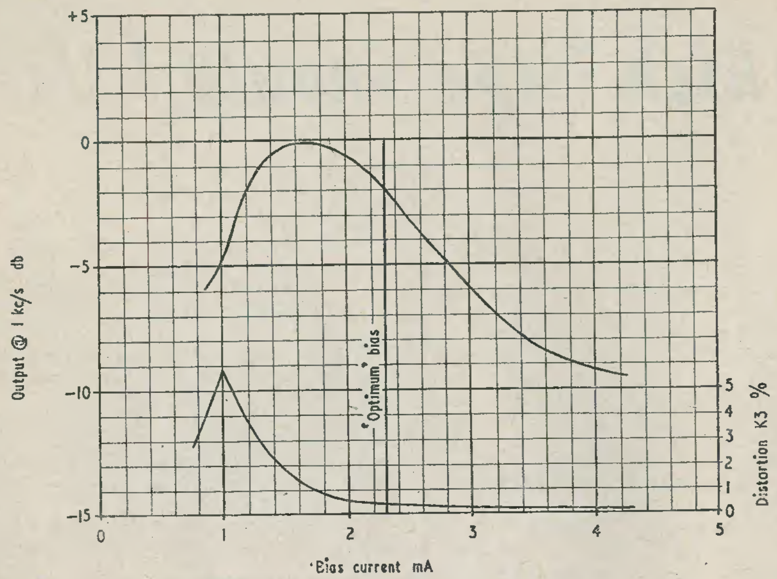


FIG. 1. INPUT LEVEL TO RECORDER 10 db BELOW FULL MODULATION

should be employed is the point at which, with increasing bias, the output has fallen 2 db from the maximum—in this instance 2.33mA. This, therefore, is the figure to which the recording amplifier is related, and at which a "flat" frequency response was obtained. (The overall response was flat within +2 db, but the three frequencies 60 c/s, 1 kc/s and 10 kc/s were almost level.) The output for 5% Third Harmonic Distortion was noted, as was the input signal required. These will be considered as reference levels and it is assumed that comparison of the two signals will give an indication of tape sensitivity.

In plotting the curves of Fig. 2, the input signal (1 kc/s) was adjusted for each bias setting to produce 5% of tape distortion. Record and playback signals were noted and related to the reference levels. By arrangement, the two curves have an identical value at bias 2.33mA, but it is interesting to note that they in fact cross at this point. Maximum tape sensitivity occurs at bias settings of 1.4 to 1.8mA. At 1.6mA the input signal needed is reduced by about 4.5 db—a useful increase of record sensitivity, but this is offset by a drop in playback level of nearly 2.5 db, which figure has to be subtracted from the signal noise ratio of the recorder. Many machines just could not afford it! If, therefore, we look for maximum output from the tape, combined with the best tape sensitivity, we come back to the point we chose originally—conventional "optimum bias."

In order to determine accurately the effects of changes in bias on the overall frequency response, measurements were taken at the three spot frequencies of 60 c/s, 1 kc/s and 10 kc/s. The results have been plotted in Fig. 3, and show at a glance the erasing effect that the recording bias has on the 10 kc/s signal. It is interesting to note that closer inspection of the 1 kc/s curve, compared to that for 60 c/s, shows a tendency towards the same effect, and allows a logical conclusion to be drawn in respect of the intermediate frequencies.

It will be seen that the amount of treble emphasis required is directly dependent upon the bias setting and, in consequence, *must* be associated with the recording.

On the basis of all the figures that have been obtained, let us examine the effect on our given tape recorder, using the tape so far considered, of the adoption of a new bias setting. An increase of bias would seem to have little to commend it. From Fig. 2 we see that no more output (for a given distortion level) can be obtained, although the input signal has to be increased. The 10 kc/s curve in Fig. 3 shows that greater treble pre-emphasis is necessary. If the bias is increased to 3mA, and assuming the necessary alterations are made to the recording amplifier, the nett result is the same playback volume, but a loss of 9 db in the gain of the record amplifier. As that experiment does not seem to be very fruitful, let us try the effect of a reduction in bias. 1.65mA seems an attractive figure, since it gives a peak in output in the curve of Fig. 1, and lies within the range of maximum tape sensitivity as shown by Fig. 2. The outlook is immediately more optimistic. Some 4¼ db less treble emphasis is needed and this, combined with the extra tape sensitivity means an effective *increase* in record amplifier gain of 8½ db. This is paid for by a decrease in playback signal of 2 db. By and large, it is not surprising that this lower figure is considered more attractive by some designers.

It has long been considered an axiom of tape recording that to reduce distortion you increase bias. Fig. 2 (replay curve) shows quite definitely that this only applies up to optimum bias, which, by its very name, will be more often used. Beyond this point, an increase in bias will certainly reduce distortion, *but only to the same degree as would a reduction in input.* If the input is increased also, to restore the replay level, the distortion is the same.

Let us now return to the question, posed in the opening paragraphs, of using a different brand of tape on our test machine. If we were to start afresh, and produce three more sets of curves, they would be remarkably like those illustrated, but with one important distinction. The curves would be shifted laterally, either right or left, with respect to the bias current scale. It is true that, having found the new optimum bias setting, slight alterations may be required to the input level for 5% distortion and to the treble pre-emphasis for a flat response. Such alterations would form the basis of a true comparison of tape quality, beyond the scope of the present article. What is important at the present time is that, on the equipment in question, various samples of tape exhibited optimum bias settings between 1.5mA and 2.75mA.

In consequence, on the tape recorder here being considered as an example, a second sample of tape could be either under or over-biased. Over-biasing, we have seen, leads to a drop in tape sensitivity and, more important, a sharp drop in treble response. Should the tape, on the other hand, be

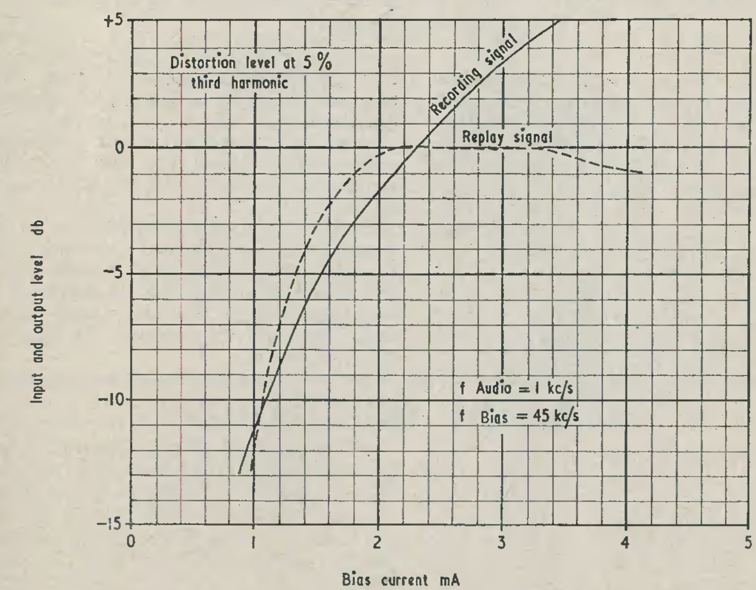


FIG. 2. CURVES SHOWING VARIATIONS OF TAPE INPUT AND OUTPUT SIGNALS WITH VARIATION OF RECORDING BIAS. ALL OTHER CONDITIONS MAINTAINED CONSTANT

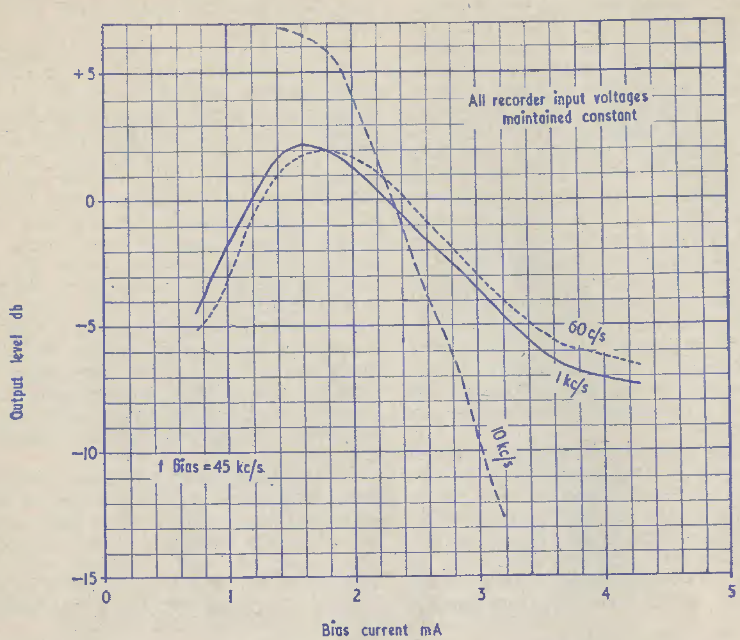


FIG. 3. CURVES SHOWING VARIATIONS OF PLAYBACK SIGNAL WITH VARIATIONS OF RECORDING BIAS AT DIFFERENT AUDIO FREQUENCIES

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under-biased, the position is rather worse. When, earlier, it was suggested that a bias setting below optimum carried advantages, it was assumed that the recording amplifier had been suitably adjusted in terms of treble pre-emphasis and record level indication. Without such adjustment the tape distortion will be too high, as will the treble response. Surely, if the aim is true "high fidelity," too much treble is as bad as too little.

Summing up, it would seem that if the facilities are available, your tape recorder can be adjusted for any tape you please, and there is even room for experiment with the bias applied to the "approved" tape. Without such facilities, however, give the manufacturer best!

It will be appreciated that all the foregoing applies to recording only—the playback of tapes recorded on other machines is unaffected.

Finally, the writer would like to give grateful acknowledgment to the Chief Engineer of Grundig (Great Britain) Ltd. for permission to make use of some of the results quoted, but would not wish to associate him with responsibility for any conclusions drawn.

MULLARD QSL CARDS

Many thousands of these cards have now been issued free of charge at considerable cost to the company, and whilst they are anxious to continue this service to amateurs, they are now reluctantly compelled to make a nominal charge for supplying and overprinting them. The cost to amateurs is given here:—

250 cards	..	£1 0 0
500 cards	..	£1 10 0
1,000 cards	..	£2 0 0

It will be seen that these charges still effect a considerable saving, as Mullard Ltd. are able to give the advantage secured by bulk printing of a considerable number of cards, the cost of the basic design, blocks, card, printing and postage still being met by the company.

Cheques, postal or money orders should be made out to Mullard Ltd. Supplies will be available within 14-21 days of receipt of remittance and order.

A Good Quality RECORD PLAYER

By N. B. JONES

REQUIRING A RECORD REPRODUCER THAT would be powerful enough to fill a small hall, but at the same time being of a reasonable size to be carried about, the accompanying circuit was evolved after much experiment.

Circuit

It can be seen that the input is fed into a 6J5 triode which is coupled to another 6J5 in the second stage. The output stage consists of a beam-tetrode of the KT66 class. This at first sight may seem rather a large valve to use for such a purpose, but with 350V h.t. it gives a power output of approx. 11 watts, which fulfils the above requirements.

Each stage is adequately decoupled, which avoids any instability that might arise owing to the relatively small chassis used.

The h.t. is supplied by a 5Z4 rectifier, and is smoothed by the choke and electrolytic condensers, with the result that there is virtually no hum.

For convenience, the mains transformer is mounted separately on the floor of the cabinet; there is no reason why it should not be mounted on the main chassis, but care should be taken to ensure that the axis of the transformer is at right-angles to the axis of the smoothing choke in order to eliminate hum.

Negative Feedback

This was introduced to remove any traces of distortion in the output stage. The value of the feedback resistor R_{16} is very critical, depending on the amount of feedback required. If its value is increased, then the amount of feedback obtained will be decreased, and vice versa.

If maximum feedback is desired, the best way of determining the value of R_{16} is to insert temporarily in its place in the circuit a 10kΩ linear potentiometer and adjust it until the point of maximum feedback is obtained, then, reading its value on a reliable meter, substitute a fixed resistor of the same value in the circuit.

The output transformer must be capable of carrying the high anode current of the KT66 and also of handling the high output, so it should thus have a generous rating. In the finished amplifier, a 15 watt transformer was used, and, like the mains transformer, it was mounted separately on the floor of the cabinet.

Tone Control

The tone control network provides for both treble and bass cut; it should be noted that the "boost" is obtained at the expense of overall output, but the high gain of crystal pick-ups and the power of this amplifier enables this circuit to be used satisfactorily.

Alternative Valves

If a less ambitious output of some 5 to 6 watts is desired, then a 6V6 or 6F6 may be substituted for the KT66 in the circuit. The cathode biasing resistor R_{15} should be altered in each case to the correct value for the valve used.

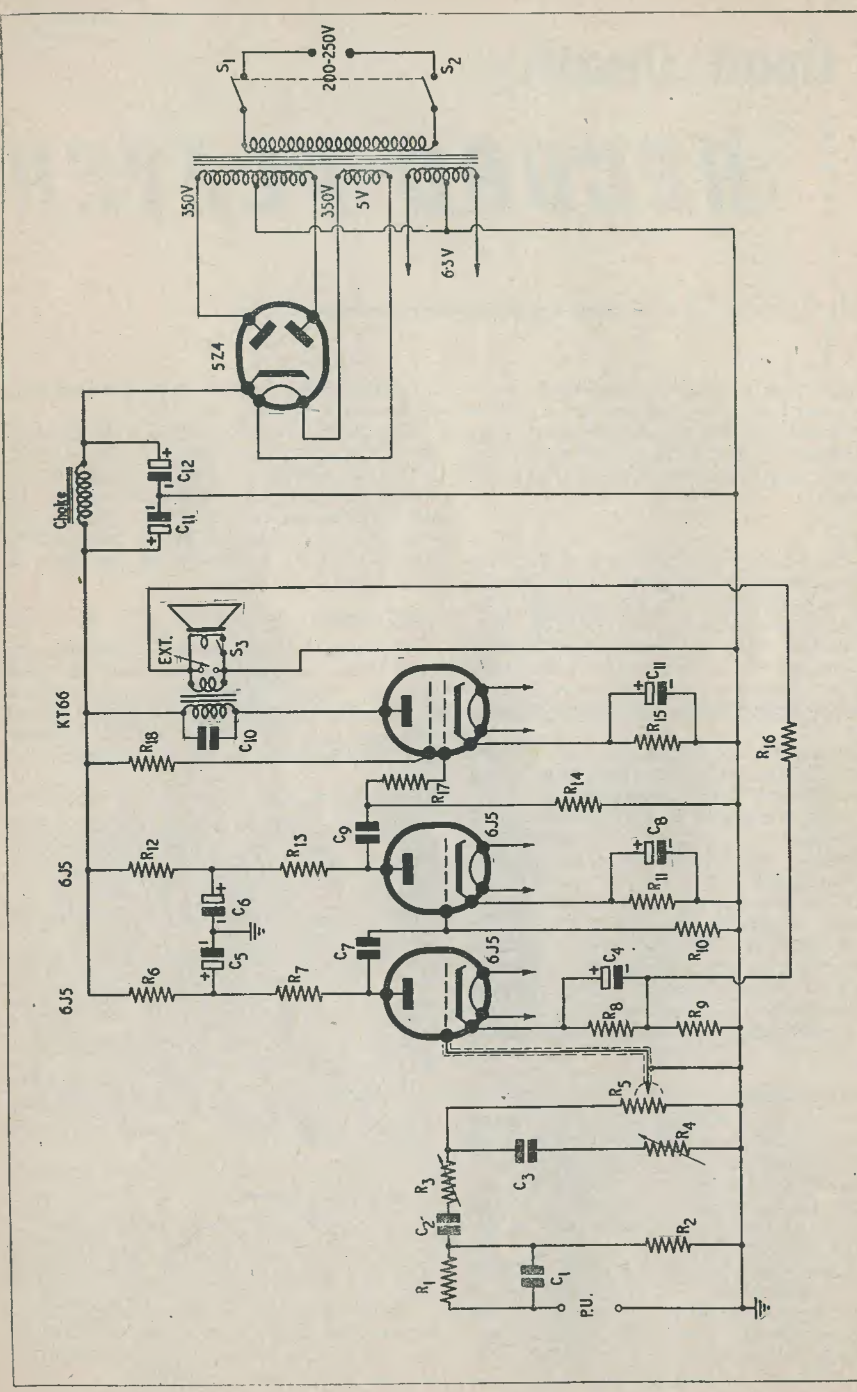
It would also be advisable to change the mains transformer for one having a 250V secondary, since if this is not done overrunning of the valves will result. The output transformer may also be changed for one with an output rated at 6 watts.

If it should be found necessary to have to alter the feedback resistor, the correct value may be found by the method previously described.

Chassis and Cabinet

The chassis was formed from a sheet of 16 s.w.g. aluminium, and the finished dimensions of it are 12in long, 3in wide and 2¼in deep.

The leads to the mains and output transformers are brought to terminal blocks on the top of the chassis, which makes the connecting up relatively easy.



CIRCUIT OF COMPLETE AMPLIFIER.

Components List

Resistors

- R_1 100kΩ ½W
- R_2 100kΩ ½W
- R_3 2 MΩ pot. lin.
- R_4 2 MΩ pot. lin.
- R_5 500kΩ pot. log. with d.p.s.t. switch (S_1 and S_2)
- R_6 20kΩ ½W
- R_7 250kΩ ½W
- R_8 1kΩ 1W
- R_9 100Ω 1W
- R_{10} 500kΩ ½W
- R_{11} 1kΩ 1W
- R_{12} 15kΩ ½W
- R_{13} 150kΩ ½W
- R_{14} 500kΩ ½W
- R_{15} 250Ω 1W
- R_{16} 5kΩ ½W
- R_{17} 50kΩ ½W
- R_{18} 100Ω ½W

Mains transformer: primary 200-250V, secondary 350-0-350V 100mA, 6.3V c.t. 4A, 5V 3A

Condensers

- C_1 0.01μF 350V wkg
- C_2 0.001μF
- C_3 470pF
- C_4 25μF 25V wkg electrolytic
- C_5 8μF 350V wkg electrolytic
- C_6 8μF 350V wkg electrolytic
- C_7 0.01μF 350V wkg mica
- C_8 25μF 25V wkg electrolytic
- C_9 0.01μF 350V wkg mica
- C_{10} 0.002μF 350V wkg mica
- C_{11} 25μF 25V wkg electrolytic
- C_{12} 16μF 350V wkg electrolytic
- C_{13} 8μF 350V wkg electrolytic

Valves

- V_1 6J5 Brimar
- V_2 6J5 Brimar
- V_3 KT66 Osram
- V_4 5Z4 Brimar

Output transformer: ratio 40:1, primary impedance 4,200Ω, secondary matched to 3Ω, output 15W

Choke: 20 Henry 100mA

S_3 On-off toggle switch

When installed, the chassis is mounted on its side, so that the potentiometer spindles project upwards through the motor board which is mounted just above the amplifier.

The cabinet was constructed from ⅜in plywood which was butt-jointed together and reinforced with ½in square blocks which were glued and pinned along the joints. The finished cabinet was covered with rexine, and the result is very pleasing in appearance.

Connecting Up

When completed, the amplifier may be connected up to the pick-up and speaker.

If there is fierce oscillation from the speaker when the amplifier has warmed up, it is an indication that the feedback is positive, i.e. functioning in reverse. This may be rectified by reversing the connections to the output transformer secondary, when the amplifier should function perfectly without any trace of instability. In the finished player, a 10in × 6in elliptical speaker was used, but it was found that the full output could not be fed into it because of acoustic feedback from the motor unit, so extension speaker sockets were added together with an internal speaker silencing switch, so that several speakers can be run off the main amplifier without any traces of acoustic feedback being present.

A Word of Warning

It is very important that adequate ventilation is provided for the output valve and the rectifier, because if this is overlooked serious damage may result to these valves, together with other adjacent components.

BOY SCOUT JAMBOREE-ON-THE-AIR, May 10-11

Dear Sir,—With reference to the recent notice submitted in respect of the above forthcoming Jamboree, there is rather an important amendment that has just come to my notice and I would very much appreciate it if a small space be allocated on the lines as follows:—

"Boy Scout Jamboree-on-the-Air, Gilwell Park, May 10th-11th." We have just been advised that the proceedings of the week-end May 10th-11th are purely in connection with the Queen's Scout Course, and that the general public are not being admitted on this occasion. The reference in the previous announcement that "visitors will be welcome, etc." applies only to members of the Scout Movement who are taking part in the above Course.

It is regretted that this was not made clear to me at the time but no doubt the above notice will clarify the position and save would-be visitors both time and unnecessary expense.

Thanking you for your kind co-operation.

Yours faithfully,
E. W. Bonson,
G3JHY

Radio Miscellany

Again this month the total of Old Timer letters swells. Old Timers they may be, but they are certainly not Back Numbers! They are invariably busy with the latest developments and seem to be among our keenest readers. They all doubt whether the hobby is quite as exciting as it used to be but, however nostalgic their memories, none has yet suggested that present-day radio journals are not as good as those of Days of Yore! In fact, they are unanimous that *R.C.* is better, and often praise their favourite features. A good thing this—it helps the Editorial staff to plan the sort of magazine you really want. I have often thought of devoting a paragraph or two to readers' "What we like and what we don't like." So if you, whether Old Timer or Beginner, have decided views about the bits you enjoy and the bits you skip, let us have them. I remember some years ago a reader gave his opinion. Of me it consisted of five words, simply "Centre Tap—waste of space." We printed it—and nobody wrote to disagree! However, I didn't get the sack because occasionally other readers said they liked it. So if you decide to write, be as candid as you like. The one who pays the piper is entitled to call the tune!

Wot! No Joy?

Two letters of particular interest. The first from Mr. D. J. Morris, who writes on the unorthodox circuits widely publicised in radio periodicals of the early twenties. Were the soft valves of which this column has recently busied itself responsible for the performances claimed for them by their designers but not repeated by those who optimistically built them? Sometimes they failed to give any results at all! This seems a very probable explanation which I have not seen put forward before. He mentions also recently reading a book on transistors and finding that Lossev successfully used similar means in crystal oscillators and amplifiers in 1924. The results of his experiments were published, and he wonders whether other readers recall them. His address is 88 Prescott Street, Birmingham 18.

Mr. Jas. Pickering, Kent House, N.W.1, also looks back to the early days of broadcasting when his father bought a crystal set. Using a spring mattress as an aerial, the whole family sat in the attic until midnight listening to the Savoy "Orpheans." Within a week he had it to pieces, much to his family's disgust, and he built a 2-valver from a pictorial diagram, which worked! As he didn't know the first thing about radio, it speaks well for this method of construction for simple receivers. He also remembers the Oojah coils—and recently ran across a couple of Igranic plug-in coils in a shop in Euston Road. For sentimental reasons he bought them. He, too, doubts whether the present-day beginner gets the thrill the 1922/23 constructor used to feel. There is one excitement he must miss. Hurriedly scanning the radio mags. to see "what's new." In those days there was always some startling innovation or "amazing" circuit. The enthusiast rebuilt at least once weekly. It was exciting and helped one to learn a lot. Nor was it as expensive as it might sound. Components could be used over and over again. Which, in case any up-and-coming fellow-me-lad doesn't know, was precisely why they were made like Meccano parts!

Who's for Which?

In the British lay press, t.v. receiver manufacturers proudly advertise the virtues of their models incorporating printed circuits. In the U.S.A. the Zenith Radio Corporation equally proudly announce (in their technical periodical advertising) "We use no printed circuitry in our t.v. chassis." Incidentally, the head of their Research Department was one of the pioneers in its development and they were among the first to use printed circuitry in the proximity fuse. They claim their standard handcrafted t.v. circuitry means greater dependability and fewer servicing headaches. Personally, I'm not so sure about the headaches but with competent engineers standard circuitry servicing is undoubtedly far less costly.

Confirmed

When the recent discussion in this column on the best value in entertainment-cum-test-value gramophone record first bubbled up, I tipped a couple of my favourites. One was originally the choice of a manufacturer and used by them for demonstration purposes. My second tip was Benjamin Britten's "Young Person's Guide to the Orchestra"—any good recording preferably without narration. This was some months back and I now see in the February *Radio-Electronics* a new recording of this is described as "a fine demonstration test and show-off recording." I particularly like the show-off bit!

Since this question was first raised by our Aberdonian correspondent I have made a point of looking out for sonically spectacular recordings, but it is going to be difficult to find another single piece of music offering such scope for a demonstration of orchestral capabilities. Would-be purchasers should be warned that a really first-class hi-fi system is required to make the most of it. It is also liable to make you dissatisfied with your present reproducer and put you to a lot of trouble and expense if you have a critical ear—or a square-wave generator!

most of our existing reproducing equipment will have to be further improved unless we are going to be content to restrict the use of 16⅔ r.p.m. records to background music, etc. Roll on the opportunity to judge for ourselves!

The Music Goes Up and Down

In the many American radio journals I've read, I have never once seen the word "gramophone" used. It is invariably "phonograph"—a name which I believe should properly be used only to describe Edison's original invention. In most of the English-speaking world both words are accorded their proper usage. The phonograph as we know it is the instrument used for playing cylindrical records, not the flat discs of the gramophone.

The matter of shape, which obviously makes for easier and safer storage in the case of flat discs, is not the only difference. On the phono cylinder the recording was "up and down"—not lateral (side to side) as on the gramophone record. The hill-and-dale system of the phonograph greatly restricts the frequency range. The early instruments (and recordings) of both systems were probably so limited in frequency range that the point was hardly thought to be of much importance. It was the comparative cheapness of making flat disc recordings that was considered the prime commercial advantage by manufacturers. This coupled with storage ease also meant customer appeal.

Some years ago I had the opportunity of examining a number of "museum pieces" from a private collection in which a selection of early flat and cylindrical records and machines (as used at the beginning of the century) had been carefully preserved. The most obvious difference in reproduction was the much greater volume obtainable from the flat discs. Once again customer appeal. Everyone likes a lot of volume for less money and history repeated itself in the early days of broadcasting. The set which gave the greatest volume proved the best seller.

Perhaps some of our veteran readers can supply further comparative details—that is providing the acoustical gramophone of those days was not felt to be too remote from radio. My first interest in the gramophone was born in the question of horn shapes when an earpiece balanced on the

Centre Tap talks about Items of General Interest

V.L.P.

The initials are of my choosing. If L.P. is used for Long Play, V.L.P. should be well suited to the new 16⅔ r.p.m. musical "Phonograph" records now available in the U.S.A. Hitherto used only for talking books, the first releases were marketed a couple of months ago under Vox labels. Each side plays for nearly an hour, and I gather that the first half-dozen released are "dub-offs" from ordinary Long Plays. Perhaps by the time you read this, other makes will have joined them and possibly they will soon be available over here. Those who have bought 4-speed motors in the last two or three years can now congratulate themselves on their foresight. Like myself, they will be anxious to try them even if not too confident of the result. So slow a speed represents a severe challenge to the steadiness of turntable drives with a danger of dragging on the heavier passages, to say nothing of the stability of amplifiers and pick-up resonances.

The quality of modern 33 r.p.m. recordings is so good that music lovers have become accustomed to such a high standard that they are harder than ever to please. I feel it is doubtful whether 16⅔ r.p.m. recordings will be fully acceptable to the hi-fi enthusiasts unless all the uncertainties I have mentioned are completely eliminated. It is certain that end of a tin trumpet was the only form of loudspeaker we knew. Immediately prior to the introduction of electrical recording, acoustic gramophones had been brought to at least a pleasing level of reproduction quality. It was surprising, too, the amount of volume which was obtainable from several feet of curled horn cunningly compressed into a reasonably small cabinet. Indeed, quite a marked "bass" response could be obtained although, not unexpectedly, the heavy sound-boxes soon broke down the walls of the grooves on heavily recorded passages. Deep, rich notes quickly disappeared in a welter of mush. Even the early pick-ups were guilty in this respect, and on more than one occasion I have bought a second disc of a recording which particularly pleased me.

With modern well-designed pick-ups the amount of wear is negligible. Personally, I have found no signs of deterioration even after dozens of playings of long-play and extended play records. Strangely enough I still have a dislike of buying a record which has been "played before"—undoubtedly a lingering prejudice from the days when record wear was appreciable! As far as I know no reliable figures of record durability have been given. Obviously much depends on pick-up design and correct tracking. I should like to buy records in sealed envelopes. There is always the danger when prospective purchasers have an "approval run" and decide not to buy, that the harassed assistant lifts off the arm somewhat clumsily—leaving a nasty click which is heard in every subsequent playing.

Reverting to the question of "hill-and-dale" recording, it is of interest to note that this system is seeing something of a revival in experimental form. Recording grooves are cut carrying both vertical and lateral stylus motion to produce stereophonic reproduction. A second system in which two separate channels are cut on opposite walls of a 45 degree groove is also being developed. Neither is likely to be available to the public until the manufacturers have agreed on a single standard, but it may not be long before stereophonic discs and suitable cartridges are marketed. So what with V.L.P. and stereophony, exciting possibilities seem imminent for the hi-fi enthusiast.

Precautions with P.V.C.

Everyone who has used p.v.c. covered wire in radio construction will have found that extreme care has to be taken when soldering wire covered with this material, otherwise the wires become exposed and the insulating properties destroyed. There must be many cases where lack of attention to the requirements of this type of covering has ended in disaster to an equipment into which, in other directions, much time and thought has gone. To the uninitiated, then, these few words are addressed in the hope that pitfalls may be avoided which bring disappointment and further expense.

Perhaps the most obvious feature of p.v.c. insulation material is its tendency to soften when subjected to even moderate heat, so that in radio chassis wiring we run full tilt into trouble by using hot solder to make good electrical contact. The soldering operation must therefore be carried out quickly and efficiently and in one "go"—it is unfair to expect the p.v.c. to withstand a second assault by the hot iron when the joint has to be made again. A clean soldering iron with pre-tinned wire and tags is a "must," and it will be found that a "heat-sink" in the form of a pair of pliers to hold the wire near to the joint being made will go a long way towards conducting excess heat away from the vulnerable covering of the wire.

Where a number of wires lie closely together a danger exists in that the proximity of the hot iron can melt the p.v.c. on several wires, creating —if not a dead short—a possible leak in a very important part of the circuit, particularly if it be high impedance circuitry.

Another point to note is that wires adjacent to or in contact with a tag being soldered can also suffer, and if under tension against the tag can be punctured sufficiently by the hot tag to penetrate and make unwanted contact. It is essential, then, to put a certain amount of planning into the route the wiring will take, ensuring that wires do not pass too near or are packed under any soldering or component tag.

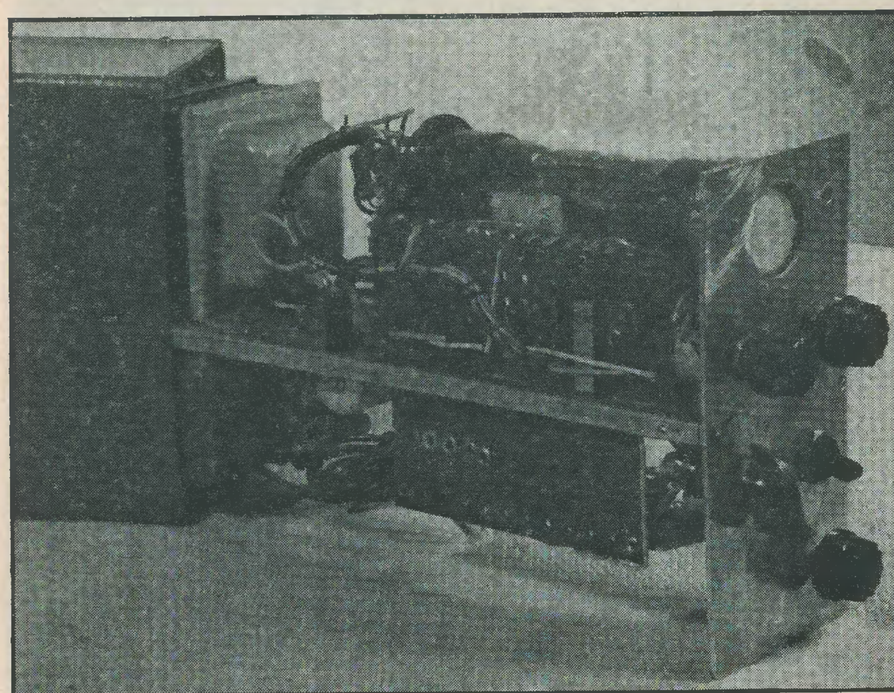
Although, as stated, the most obvious dangers occur when p.v.c. becomes warm, there are also unfortunately instances where it can be damaged in its cold state. It tears easily; and whilst it appears to be a simple operation to tear the insulation off the end to be soldered with a pair of side-cutters, the well-known "wire-stripper" is to be preferred to ensure a good clean termination of the covering.

Where a wire turns a sharp corner, possibly through a hole in the chassis, care must be taken in making the bend. Rubber grommets should be used where possible as the rough burrs left on the edge of the hole are quite enough to break through the covering, especially if a number of wires pass through together. A very tight grip by the bending pliers can also cause damage, and here round-nosed pliers should be used gently in order to minimise it.

Finally, do not clamp p.v.c. wiring down too tightly as it can "spread out" under pressure and become thinner, presenting another possible source of breakdown. It is perhaps superfluous to remark that leaks caused by leakage through bad insulation cannot be traced by a simple continuity tester. Very often only the application of working voltages will cause a failure, and it is then too late—particularly where such things as valves are concerned.

An Ultra-Simple OSCILLOSCOPE

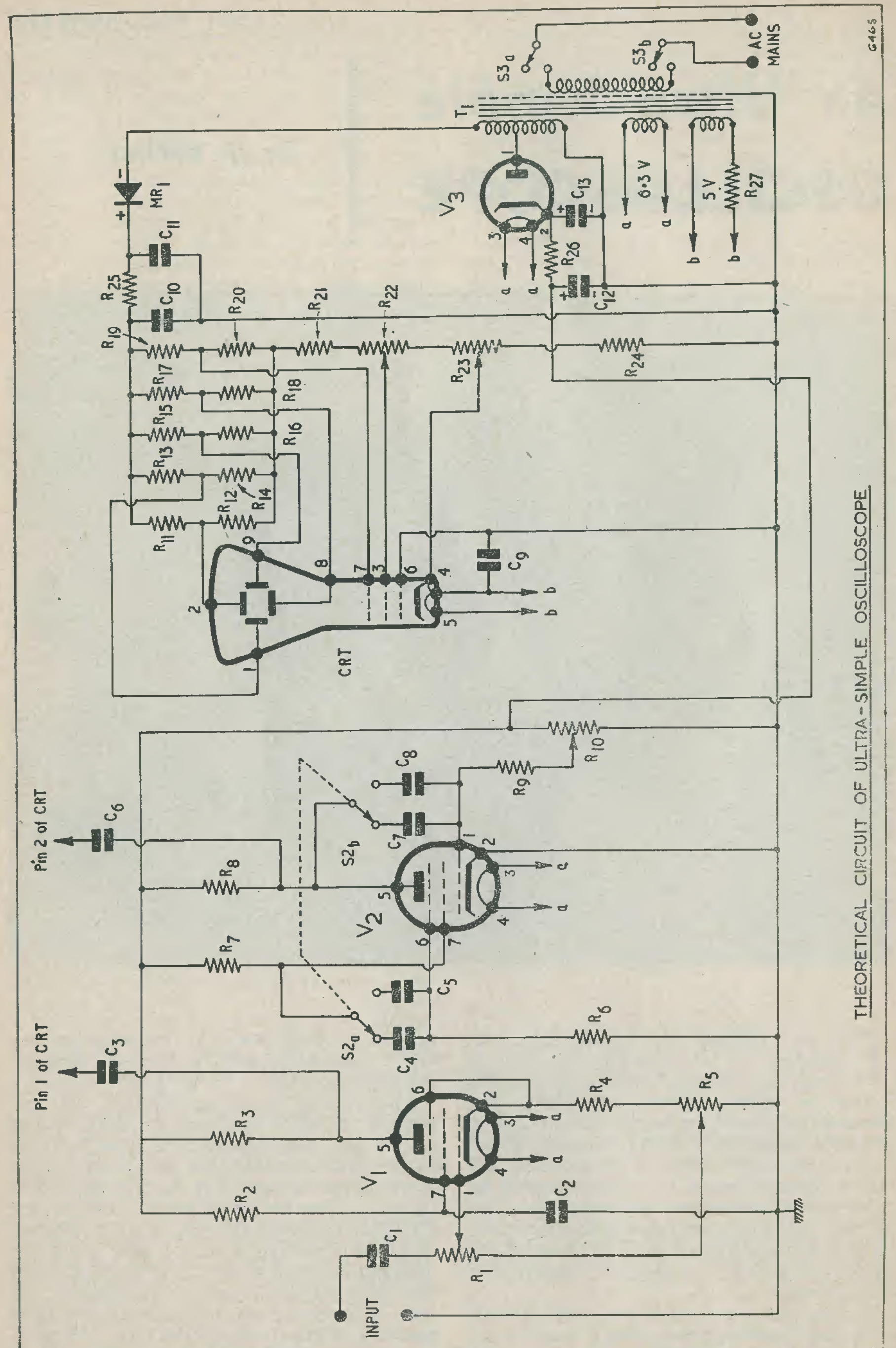
By M. Barber



THE OSCILLOSCOPE TO BE DESCRIBED WAS designed to be carried in the pannier box of a motorcycle when going to the rescue of distant friends who have just learned that the thing in the middle of the test card should be a circle. As such, it had to be robust and simple in the extreme and not to require hours of knob-twiddling in other people's homes. It has served its purpose admirably for several months now; indeed, it has relegated the big 'scope in the workshop to the position of electrostatic dust-collector.

A $1\frac{1}{2}$in c.r.t. was used to keep the size and e.h.t. requirements down, and a surprisingly clear and readable trace is obtained. The original tube carries A.M. lettering but the G.E.C. equivalent used in their "Miniscope" is still obtainable.

The circuit is simple enough for the beginner to tackle and needs very little setting up. T_1 is an ordinary replacement transformer, fully shrouded for preference, which is connected to give 250V for h.t. and 500V for e.h.t. The heater of the h.t. rectifier, an EY91, is fed from the 6.3V winding, along with the other valves in the unit, while the tube heater, rated at 4V 1A, is supplied from the 5V winding through a 1Ω resistor. If this is unobtainable, a 3in length of 1kW electric fire spiral will do the trick. Wind it on to a big ceramic tubular condenser and



THEORETICAL CIRCUIT OF ULTRA-SIMPLE OSCILLOSCOPE

twist the ends round the condenser lead-out wires. The rest of the power supply is conventional except the use of resistance smoothing in the h.t. line. This is adequate for the current taken by the unit as well as saving the bulk of a choke.

The voltage divider network for the X and Y plates of the c.r.t. may appear curious and call for comment. The values of R_{16} and R_{18} are adjusted by substitution during initial testing of the instrument, to bring the trace to the centre of the screen. Thus the usual shift potentiometers are dispensed with and since work voltages are always applied through the Y amplifier, no spurious d.c. appears on the deflector plates to make centring adjustments necessary. The grid of the c.r.t. is returned to h.t.— and brilliance controlled at the cathode, so as to wring the last volt or two out of the 600V or so of e.h.t. available. Beam blanking on flyback was considered an unnecessary complication and was omitted.

The timebase, a normal transitron is built round V_2, an EF91 or similar, and since it was visualised that the 'scope would be used mainly for checking timebase waveforms in t.v. receivers, two frequency ranges only are provided. These cover 5–500 c/s and 1,000–12,000 c/s selected by a double-pole two-way wafer switch. Thus horizontal and vertical deflection frequencies are covered and video waveforms can be displayed. Fine frequency control is effected by R_{10}. No special provision is made for synchronising to the work voltage—radiation from the receiver under test is sufficient to lock the trace solid!

The Y amplifier V_1 is another EF91 with a voltage gain of about 25. This can be reduced to unity by opening S_1, thus inserting R_5 into the cathode return and enabling the amplifier to handle signals which would normally be applied direct to the Y plates and dispensing with shift controls as outlined above. The "volume control" is operative in both gain positions.

Construction should follow normal 'scope practice, with the mains transformer mounted behind the tube; with only 6 controls and a 1½in screen to accommodate on the front panel, the complete instrument can be made almost pocket-size. In fact, the original version carries only four controls on the front panel, the brilliance and focus controls being pre-set types mounted "on the side" and adjusted occasionally through holes in the case. The front end of the c.r.t. is lightly clamped by a 1½in condenser clip lined with cycle patching rubber. This, combined with a thin, flexible sheet metal bracket for the base of the tube, gives quite a good shock-proof mounting.

Components List

Resistors

- R_1 1MΩ potentiometer
- R_2 100kΩ ½W
- R_3 33kΩ ½W
- R_4 330Ω ½W
- R_5 10kΩ potentiometer
- R_6 470kΩ ¼W
- R_7 47kΩ ½W
- R_8 200kΩ ½W
- R_9 1MΩ ¼W
- R_{10} 500kΩ potentiometer
- R_{11-20} 330kΩ ¼W (see text)
- R_{21} 1MΩ ½W
- R_{22} 1MΩ potentiometer
- R_{23} 500kΩ potentiometer
- R_{24} 2.2kΩ ½W
- R_{25} 100kΩ ½W
- R_{26} 1.5kΩ 5W
- R_{27} 1Ω 2W

Condensers

- C_1 0.1μF 750V
- C_2 0.1μF 350V
- C_3 0.1μF 500V
- C_4 100pF mica
- C_5 0.01μF 350V
- C_6 0.1μF 350V
- C_7 47pF mica
- C_8 0.01μF 350V
- C_9 0.01μF 150V
- C_{10}, C_{11} 0.05μF 750V
- C_{12}, C_{13} 8μF 350V

Valves, etc.

- V_1, V_2 EF91, Z77, etc.
- V_3 EY91
- MR_1 K3/40
- C.R.T. E4103/B/4 (G.E.C.)

Miscellaneous

- S_1 Single-pole on-off toggle
- S_2 2-pole 2-way wafer
- S_3 Double-pole on-off toggle
- T_1 Mains Transformer:
  Secondaries 250-0-250V 60mA; 6.3V 3A; 5V 2A

Avo Instruments Cross Antarctica

Several instruments were selected by the British Trans-Antarctic Expedition for use in the Antarctic and readers will be interested to know that Avo Ltd. have received a telegram telling them that several of these instruments crossed Antarctica with the Expedition.

Following the outstanding performance of Avo instruments with the British North Greenland Expedition, Avo Ltd. are very proud indeed to be able to refer to this latest achievement of British instruments.

The Avo instruments supplied to the Expedition were not specially made, they were standard models taken from the production line and calibrated for use at low temperatures.

A GRAPH FOR DETERMINING THE VALUES OF CONDENSERS IN SERIES HEATER CHAINS

By V. T. ROLFE

The practice of using a capacitor instead of a resistor in series heater chains is probably already well known to many home constructors. There are two main advantages to using a capacitor instead of a resistor. Firstly, no power is dissipated in the capacitor. Apart from any considerations of economy, this will mean that less heat is dissipated in the receiver, which is an important factor if size is to be kept to a minimum. Secondly, there is no surge when switching on, or rather the capacitor tends to limit the surge. Receivers using series capacitors take rather a long time to warm up.

The formula for calculating the value of capacitor required is rather complicated, and when alternative designs are being considered, the calculation is tiresome. The value of C is given by:

$$C=\frac{1000\ I_H}{2\pi f\ \sqrt{V_M{}^2-V_H{}^2}}\mu F$$

where I_H = Heater current in mA
f = Mains frequency = 50 c/s
V_M = Mains voltage in volts
V_H = Total heater voltage of series chain in volts

It will be found that the more voltage there is to drop across the capacitor, the lower the value of C. Also C is directly proportional to heater current, so the more current we require to pass, the higher the value of C.

To simplify calculation, a graph has been devised from which the value of C can be determined directly. It really consists of two graphs, the first of which gives a value for $\sqrt{V_M{}^2-V_H{}^2}$, which is the voltage across the capacitor. This value is then used to read off the value of C from the second graph.

The method of using the graph is as follows. The quadrants centred on the bottom left-hand corner represent various values of mains voltage. Select the one required and also the total heater voltage of the series chain along the base line. The intersection of these two lines will give a value of V_C. Trace this V_C line across the graph to the right-hand side, and find the point where it intersects the required value of I_H (read along the top scale). The value of C required is that lying nearest to this point.

This can best be illustrated by taking an example. It is required to operate the UCH42, UF41, UBC41, UL41 and UY41 in a series chain from 200V a.c. mains.

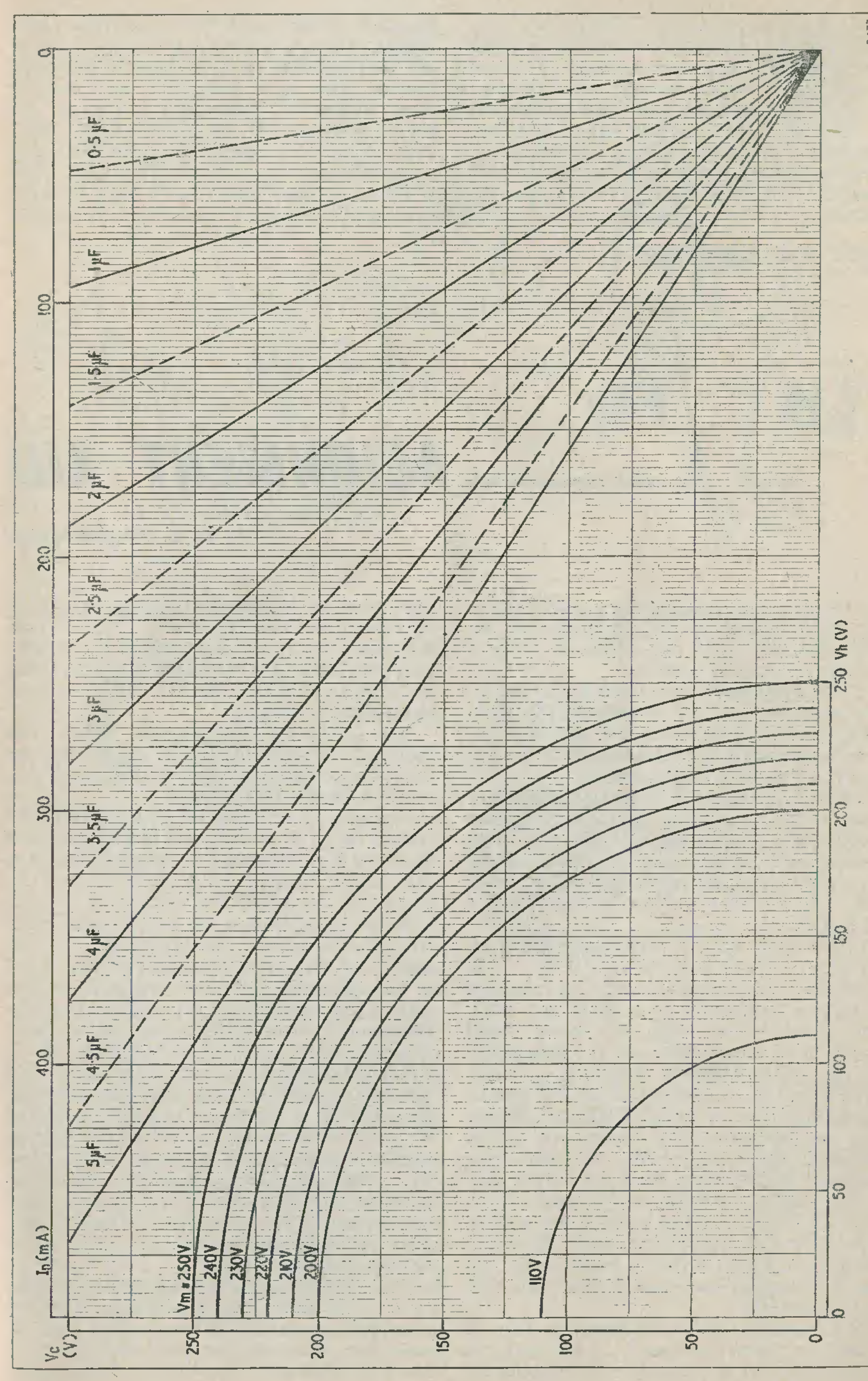
The total heater voltage is 116V, and from the graph the intersection of the 200V curve with the 116V line gives a value for V_C of 162V. Tracing this across the page, and plotting against the 100mA line (the heater current of the "U" series), the value of capacitor nearest to the resultant point is 2μF.

Should the resultant point be some distance from any of the capacitor lines, there are two possible solutions. The first is to determine either by interpolation or calculation the exact value of capacitor to be used, and use two or more capacitors in parallel to give this value, or to use a small series resistor. A further example will illustrate this method. The total heater voltage of a 300mA series is 95V, and it is required to operate this series from 220V a.c. mains. Working through as before, this will give a capacitor voltage of 200V and a value of capacitor between 4.5 and 5μF. The exact value can be found from the formula and is 4.77μF. This could be made up approximately by a 4μF, 0.5μF and 0.25μF in parallel.

The alternative method would be to use a 5μF. From the graph we find that the voltage drop across a 5μF at 300mA is 190V; projecting this on to the 220V curve, we find that the voltage across the heater chain is 112V, an increase of 17V. This can be taken up by a small series resistor of approximately 56Ω (i.e. 17V at 300mA).

In all cases a good quality paper capacitor should be used, with a working voltage 1.4 times the a.c. mains voltage.

An interesting point to note is that for values of heater voltage up to about 40V, the heater voltage itself has very little effect on the current flowing in the circuit, this being dependent on the mains voltage and



value of series capacitor. This feature may prove useful to constructors wishing to build valve testers. The heater voltages of valves for parallel operation are 4V and 6.3V (also 5V for some rectifiers) and these values can be obtained from a tapped heater winding. The heater voltages for series operated valves, however, cover a range of values from 6.3V upwards. All these valves, however, can be grouped under their heater currents into 100mA, 150mA, 200mA and 300mA ranges, and four switched capacitors would therefore provide these four heater currents with a close degree of accuracy, providing the heater voltage was not above 40 or 50V. Typical values for operation from 240V a.c. mains would be 1.33μF (100mA), 2μF (150mA), 2.66μF (200mA) and 4μF (300mA).

TEST EQUIPMENT

AM FM ALIGNMENT AID

By **A. S. CARPENTER**

EVEN AN UNCALIBRATED SIGNAL GENERATOR is better than no generator at all, especially when one wishes to know if an f.m. i.f. strip is working.

Whilst most newly constructed a.m. superhets with 465 kc/s i.f. stages usually yield some sort of signal when first switched on, their f.m. contemporaries are apt not to, due usually to severe misalignment.

A simple generator is neither expensive nor difficult to construct, and a suggested arrangement is illustrated in Fig. 1. This supplies an audible signal at either of the intermediate frequencies of 10.7 Mc/s or 465 kc/s. Other ranges are possible by changing the inductors.

V_1 generates the r.f. oscillations whilst V_2 provides the necessary audio note. This latter may be switched on or off as required.

Teletron inductors, types EO2 and EO4, are suitable, fixed capacitors being wired across them to roughly set the frequency, C_2 providing sufficient variation. Home-made inductors can, however, be used and L_1 should comprise 18 turns of 30 s.w.g. enamelled copper wire, close-wound on a ½in diameter, air-cored former, the tap being made at the sixth turn from the earthy end. In this case C_a will not be required. Similarly, L_2 may consist of a discarded section of a 465 kc/s i.f. transformer, some fifty turns being unwound in order to establish the tap and then wound back on. C_1 will not then be required.

The modest power requirements can be picked up from the chassis under test; but a more satisfactory method is to provide the unit with an independent power supply as illustrated in Fig. 2, where a small pre-amplifier type transformer is used in conjunction with one of the miniature contact-cooled rectifiers and a small, tubular, double-section electrolytic capacitor.

All oscillating components should be mounted sub-chassis, and it might also be desirable to bond a plate of 16 s.w.g. aluminium across the bottom.

Testing.—On completion, the slider of R_1 should be set to the top end of its travel and a pair of high resistance phones plugged into the output socket when it will soon be evident if the valves are oscillating or not. Should no audio note be heard, reverse the connections to the secondary of T_1. On receipt of the audio signal the values of C_7 or C_8, or both, may be varied to provide a suitable tone. Should V_1 fail to oscillate change R_4 to a slightly lower value. Incidentally, if R_4 is disconnected from pin 6, V_1, and connected instead to one end of a 50kΩ potentiometer, the other end of which is connected to chassis and its slider soldered to pin 6 of the valve, it will be possible to tune in transmissions on the 30-metre band by switching the appropriate inductor, coupling an aerial loosely to it, and using the potentiometer as a regeneration control. The modulation should, of course, be switched off.

Practical Use.—Whilst accurate calibration of the generator is desirable, it is not absolutely essential. When dealing with i.f. amplifiers designed for 10.7 Mc/s one can assume, providing standard miniature i.f. transformers of reputable manufacture are used, that the correct frequency occurs when the cores are slightly less than half embedded in their respective windings as viewed from the *open* ends. These can initially be so set and the output from the generator tuned to maximum by means of C_2. One may then assume that this is indeed 10.7 Mc/s and proceed accordingly. However, accurate calibration is a better proposition.

On range 2 things are easier, the iron dust cores used in modern a.m. frequency changer circuits permitting considerable variation, and the i.f. may, in fact, lie anywhere between 460 and 480 kc/s, the higher frequency being preferable in some cases.

Conclusion.—For details of f.m. alignment procedures refer to the following issues of this journal: June 1955, August 1956.

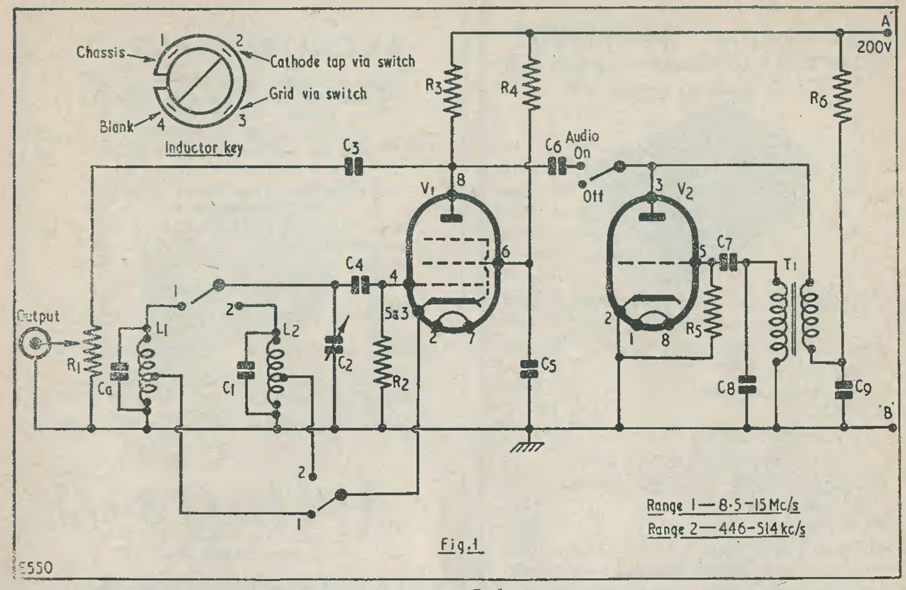


Fig. 1

Resistors
- R_1 100kΩ pot
- R_2 250kΩ
- R_3, R_5 100kΩ
- R_4 220kΩ
- R_6 33kΩ

Capacitors
- C_a 47pF (see text)
- C_1 300pF (see text)
- C_2 100pF J.B. Air tune—type C.804
- C_3 5,000pF
- C_4 100pF
- C_5, C_9 0.01μF
- C_6 2,000pF
- C_7, C_8 5,000pF (see text)

Valves
- V_1 6SH7
- V_2 P61

Inductors
- L_1 Teletron type EO4 (see text)
- L_2 Teletron type EO2 (see text)

Switches
- 1 2-pole 2-way
- 1 toggle type

Transformer
- T_1 L.F. intervalve type, ratio 1:3 or similar

Miscellaneous
- 1 I.O. valveholder
- 1 M.O. valveholder
- 1 coaxial plug and socket
- Chassis approx. 8in × 4in × 1½in
- Nuts, screws, etc.

Components required for Fig. 2 are mentioned in text.

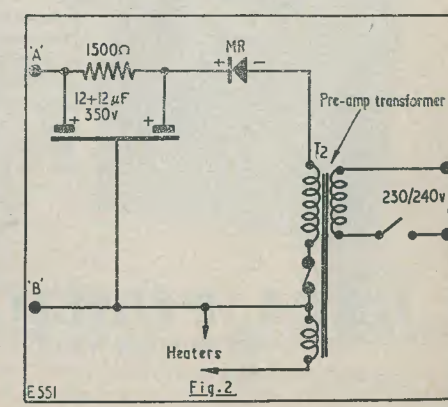


Fig. 2

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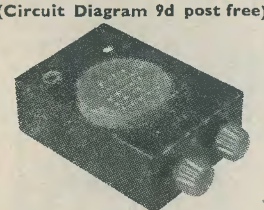
★  ★

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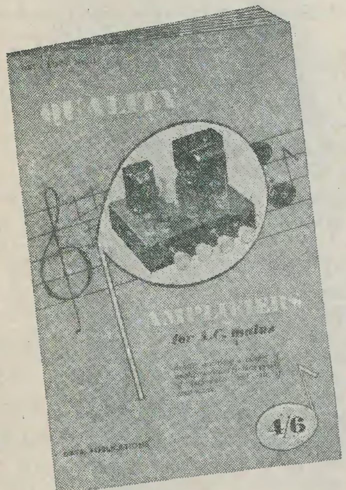

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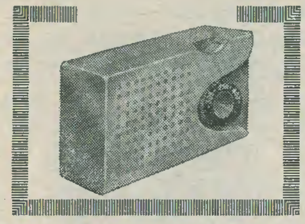

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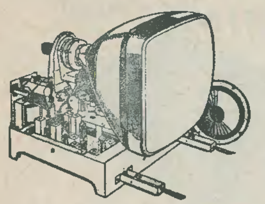

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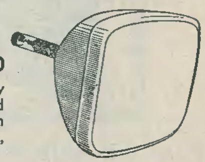

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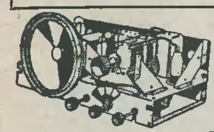

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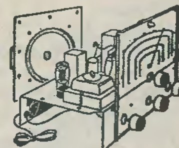

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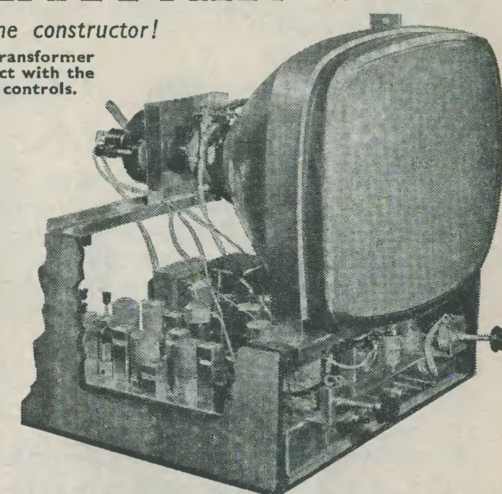

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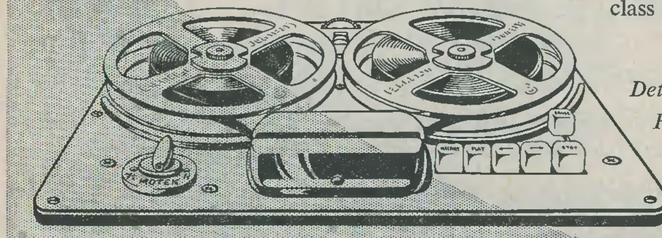

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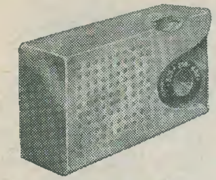

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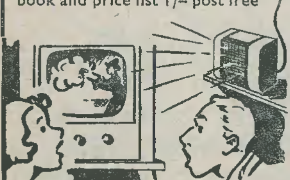
Enjoy your leisure free from anxiety. This extremely sensitive unit may be installed in a matter of minutes, is completely SAFE and thoroughly reliable. Finished in Red and Grey "LIONIDE." For use on A.C. mains 200-250V. In kit form, complete with mike ONLY **72/6** plus p. & p. 2/6, or assembled and tested **89/6** plus p. & p. 2/6. Suitable mike lead available 3d. a yd. extra. Instruction book and price list 1/- post free



★ MULLARD 510 ★
HIGH FIDELITY AMPLIFIER

We are proud to be able to offer our **printed circuit** version of this excellent amplifier, with ULTRA-LINEAR PUSH-PULL output stage, giving an exceptionally high quality output of 10 watts (max.). Built-in controls are provided for independent bass and treble tone correction to suit all types of signal input. Will match all crystal or high impedance magnetic pick-up heads, f.m., a.m. or a.m./f.m. tuners or tape recorder output. All required components of best quality to Mullard Spec. are offered at a **special inclusive price of £9 9s. plus 3/6 p. & p.** Instruction Book, containing full constructional details, theoretical, practical wiring diagrams, itemised price list available separately at 3/6 post free.

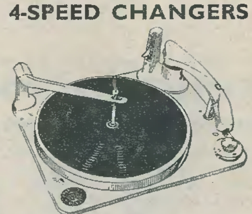
6½" WAFER TYPE LOUDSPEAKER. 3 ohm speech coil. Few only. BRAND NEW, **22/6** plus 1/- p. & p.

WIRING WIRE. Five 10yd coils in different colours, contained in cellophane bag. **5/-** per bag plus 9d. p. & p.

VALVES. We have perhaps the most up-to-date valve stocks in the trade. A stamp will bring complete list of brand new imported valve types, fully guaranteed, P.T paid. Also all usual surplus types available such as 6V6GT, 6X5GT, etc.

ALL "TELETRON" COMPONENTS IN STOCK

4-SPEED CHANGERS



B.S.R. MONARCH. Mixer autochanger in cream and gold, **£8.15.0,** plus p. & p. 3/6. Stocks rapidly diminishing

THE LATEST COLLARO "CONQUEST" 4-speed autochanger in cream with Studio "O" insert, **£8.19.6**, plus p. & p. 3/6

SINGLE UNITS

COLLARO AC 3/554. Three-speed single player for a.c. mains 200/250V. Cream finish, complete with turnover crystal pick-up incorporating the well-known high output "T" type head. Strictly limited quantity at **£6.19.6,** plus 3/6 p. & p.

COLLARO 'JUNIOR' 4-SPEED single record unit with separate pick-up and HGP59 crystal cartridge. Brand new, few only, **£4.12.6,** plus **6/3** p. & p.

CABINETS to suit all types of equipment. Price from **45/-**. Send stamp for fully illustrated list.

TRS

Our specialised buying knowledge and reputation ensure a square deal . . .

offer the best for your money!

BAND III TV CONVERTER
180 Mc/s—205 Mc/s

Suitable London, Birmingham, Northern, Scottish and Welsh ITA transmissions

Mk. 2 Model. Latest Cascode circuit using ECC84 and EF80 valves giving improved sensitivity (12 db) over standard circuits, built-in power supply a.c. 200-250V. Dimensions only 6½" x 3", ht. 4". Simple and easy to fit—only external plug-in connections. Wired, aligned and tested ready for use. State channel required. Guaranteed. Bargain offer—good results or full refund, only **£3.19.6** Carr. and pkg. 2/6

Band I/Band III changeover switch and B.B.C aerial socket can now be fitted and wired to the above converter for 8/- extra

FM TUNER-UNIT (87 Mc/s–105 Mc/s) by **Jason.** Designer Approved Kit of Parts for only **5 gns,** post free. Set of 4 spec. valves **30/-**, post free. Illustrated handbook with full details, 2/-, post free. 48-hr alignment service, **7/6**, p. & p. 2/-

CONDENSERS. Mica or S. Mica. All pref. values. 3pF to 680pF, **6d.** each. Ceramic types, 2.2pF to 5,000pF, **9d.** each. Tubulars, 450V, Hunts and T.C.C. 0.0005, 0.001, 0.005, 0.01 and 0.1, 350V, **9d.**; 0.02, 0.05, 0.1, 500V Hunts, T.C.C., **1/-**; 0.25 Hunts, **1/6**; 0.5 Hunts, **1/9**; 0.001 6kV T.C.C., **5/6**; 0.001 20kV T.C.C., **9/6**

RESISTORS. Pref. values 10 ohms 10 megohms, 20% tol., ¼W, **3d.**; ½W, **5d.**; 1W, **6d.**; 2W, **9d.**; 10% tol., ½W, **9d.**; 5% tol., ½W, **1/-**; 1% h-stab., ½W, **2/-**

PRE-SET W/W POTS. TV knurled slotted knob type. 25 ohms to 30,000 ohms, **3/-**; 50,000 ohms, **4/-**; 50,000 ohms to 2 Megohms (carbon), **3/-**

S.T.C. RECTIFIERS. E.H.T. types, K3/25 2kV, **5/-**; K3/40 3.2kV, **6/9**; K3/45 3.6kV, **7/3**; K3/50 4kV, **7/9**; K3/100 8kV, **13/6**, etc. Mains types: RM1 125V 60mA, **4/9**; RM2 125V 100mA, **5/6**; RM3 125V 120mA, **7/6**; RM4 250V 250mA, **16/-**; RM4B type 250V 275mA, **17/6**, etc.

LOUDSPEAKERS. P.M. 3 ohm, 2½" Elac, **16/6**; 3½" Goodmans, **18/6**; 5" R. & A., **17/6**; 6" Celes., **18/6**; 7" x 4" Goodmans, **18/6**; 8" Rola, **20/-**; 10" R. & A., **25/-**

SPEAKER FRET. Expanded bronze anodised metal; 8" x 8", **2/3**; 12" x 8", **3/-**; 12" x 12", **4/3**; 12" x 16", **6/-**; 24" x 12", 8/6, etc. **TYGAN FRET** (Murphy pattern): 12" x 12", **2/-**; 12" x 18", **3/-**; 12" x 24", **4/-**, etc.

RECORD PLAYER CABINETS

Contemporary style rexine covered cabinet in two-tone grey and green. Size 18¼" x 13½" x ht. 8½", fitted with all accessories, including speaker baffle board and plastic fret. Space available for all modern amplifiers and autochangers, etc. Uncut record player mounting board 14" x 13". Cut mounting boards available.

Cabinet Price £3.3.0 Carr. and ins. 3/6

2-VALVE AMPLIFIER Mk. 1. 200/250V a.c. modern circuit with high gain EL84 output and double wound mains transformer, variable tone and volume controls, wired and tested with 6" Speaker and o/p trans., complete with knobs and drilled ready to fit baffle-board in above cabinet. Only **£3.12.6.** Carr. and pack. 2/6

2-VALVE AMPLIFIER Mk. 2. 200/250V a.c. Specification as above but a higher fidelity and greater output (approx. 3 watts) is obtained by using latest twin stage triode-pentode valve ECL82 and negative feedback tone control. Complete, wired and tested as above, **£3.19.6,** carr. and pack. 2/6

RECORD PLAYER BARGAINS

SINGLE PLAYERS. 4-speed **BSR** (latest model, TU9), **92/6**; 4-speed **COLLARO JUNIOR, £4.10.0;** 4-speed **GARRARD** (4 S.P.), **£7.15.0,** carr & ins. **3/6**

AUTO CHANGERS. 4-speed **BSR** (UA8), **£8.10.0;** 4-speed **COLLARO, £8.15.0;** 4-speed **GARRARD** (RC120/4H/2), **£10.5.0,** carr. and ins., 4/6. All above models brand new and guaranteed. Fitted latest style lightweight Xtal P.U. with turnover head and twin sapphire styli

VOLUME CONTROLS Log. ratios, 10,000 ohms–2 Megohms. Long spindles. 1 year guarantee. Midget Ediswan type.

No Sw.	S.P.Sw.	D.P.Sw.
3/-	4/-	4/9

Linear Ratio, 10,000 ohms –2 Megohms. Less switch, 3/- each. **Coax Plugs, 1/2. Coax Sockets, 1/-. Couplers, 1/3.** Outlet **Boxes, 4/6**

80 *ohm cable* **COAX**

STANDARD ¼" diam. Polythene insulated. Grade "A" only. **8d. yd.**

Special. Semi-air spaced polythene. 80 ohm. **Coax** ¼" diam. Stranded core. Losses cut **50%**. Ideal Band III, **9d.** yd

MAINS TRANSFORMERS. Made in our own workshops to top grade spec. Fully interleaved and impregnated. **RADIO AND AMPLIFIER TYPE** 250V 60mA, F.W. sec., 5V or 6.3V 1A rect. 6.3V 2.5A set htrs., **22/6,** etc. **C.R.T. HTR. ISOLATION TUBE.** Low leakage with or without 25% sec. boost voltage. Ratio 1 : 1 or 1 : 1.25, 2V, 4V, 6V or 13V, **10/6** each. Ditto with mains primaries 200/250V, **12/6** etc.

L.F. CHOKES—10H 65mA, 5/-; 15H 100mA, **10/6**; 10H, 120mA, **10/6**; 20H 150mA, **15/6**

OUTPUT TRANSF.—Standard pentode, **4/6**; push-pull 12 watt, **13/6.** Small pentode, **3/9.** Midget battery pentode (1S4, etc.), **4/6**

ELECTROLYTICS—ALL TYPES—NEW STOCK

Tubular —Wire Ends		Can Types, Clips **3d.** each	
25/25V, 50/12V	1/9	8+8/450V T.C.C.	4/6
50/50V, 4/500V	2/-	8+16/450V Hunts	5/-
100/25V, 2/450V	2/-	16+16/450V T.C.C.	5/6
8/450V B.E.C.	2/3	32/350V	4/-
8/500V Dub.	2/9	32+32/275V Hunts	4/6
8+8/500V Dub.	4/6	32+32/450V T.C.C.	6/6
8+16/450V T.C.C.	5/-	250/350V B.E.C.	8/6
16/450V B.E.C.	3/6	100+200/275V	12/6

MIDGET TRANSISTOR TYPES. 2µF, 4µF, 8µF 6V, **3/6**; 6µF, 10µF, 16µF 3V, **3/6**; 32µF 1½V, **3/6**

8" P.M. SPEAKER (3 ohms)

Ex. Mfrs.' Units: Rola, W.B., Celestion, etc. All reconditioned and guaranteed. Ideal ext. unit. Bargain, **7/6**, carr. 1/6

VALVES—NEW BOXED—ALL GUARANTEED
1R5, 1T4, **7/6**; 1S5, 1S4, **7/6**; 3S4, 3V4, **8/-**; 5Z4, **9/6**; 6AT6, **8/6**; 6K7, **6/6**; 6K8, **8/6**; 6Q7, **8/6**; 6SN7, **8/6**; 6V6, **7/6**; 6X4, **7/6**; 6X5, **7/6**; 7C5, **9/-**; 7Y4, **8/6**; DAF96, **9/-**; DF96, **9/-**; DK96, **9/-**; DL96, **9/-**; 35L6 **10/6**; EABC80, **9/6**; EB91, **6/6**; EBC41, **10/6**; EVC33, **8/6**; ECC84, **12/6**; ECH42, **10/6**; ECH81, **10/6**; ECL80, **10/6**; EF41, **10/6**; EF80, **10/6**; EF86, **12/6**; EF91, **8/6**; EY51 **12/6**; EZ40, **8/6**; EZ80, **8/6**; MU14, **9/6**; PCC84, **10/6**; PCF80, **10/6**; PCF82, **10/6**; PCL83, **12/6**; PL81, **12/6**; PL82, **10/-**; PL83, **11/6**; PY80, **9/6**; PY81, **9/6**; PY82, **8/6**; U22, **8/6**; U25, **12/6**; UY41, **8/6**

SPECIAL—1R5, 1T4, 1S5, 1S4 or 3S4 or 3V4 per set **27/6**

TRS RADIO COMPONENT SPECIALISTS

70 Brigstock Road Thornton Heath Surrey *Telephone* THO 2188

Hours 9 a.m.–6 p.m. 1 p.m. Wed. *Terms: C.W.O. or C.O.D.* *Post and packing up to ½lb 7d., 1lb 1/1, 3lb 1/6, 5lb 2/-, 10lb 2/9.* *Bargain lists 3d.*

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(RADIO) LTD

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OPEN MONDAY to SAT. 9–6 THURS. 1 o'clock

HUNDREDS OF BARGAINS AVAILABLE IN TRANSISTOR COMPONENTS, VALVES, ETC. TELETRON and REPANCO Products in Stock SEND 6d. for 28-PAGE CATALOGUE

TRANSISTORS
JUNCTION TYPE P-N-P

RED-SPOT 800 kc/s Audio Frequency ...	7/6
BLUE-SPOT 1.6 Mc/s I.F. and R.F.	15/–
WHITE-SPOT 2.5 Mc/s R.F. and I.F. Amp.	15/–
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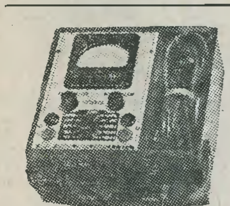
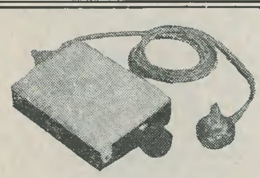
TRANSISTOR BASES ... ... **9d. each**

TRIPLETT AC/DC POCKET TEST-METER Type 666H—15 ranges, 1000 ohm p. volt, AC/DC 10/50/250/1000/5000V, **Milliamps** 0–10/100/500, **Ohms** 0–300/250,000, **£5 . 10 . 0** In new condition with prods and internal battery



U.S.A. TESTMETER
Type "834-S"
AC/DC 15 Ranges
AC/DC Volts 12/60/300/600/1200/6000
Milliamps 1.2/12/60/600
Ohms 0–5,000/5 meg
F.S.D. 1,000 o.p.v.
£6 . 19 . 6

TRANSISTOR SQUARE WAVE GENERATOR
Complete Kit with 2 Transistors, components, circuit and plastic case 20/–

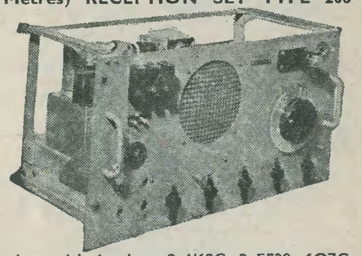


MINI-TWO
2-TRANSISTOR MINIATURE POCKET RADIO

The smallest transistor set offered on the market. Variable tuning. Drilled chassis, plastic case size 3" x 2" x ¾", miniature hearing aid, 2 transistors and all components including 1½ volt battery, circuits and full practical layout diagrams.

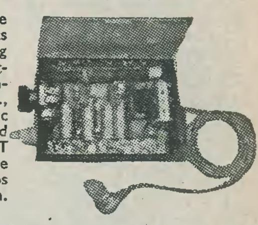
Total cost **47/6** complete

SPUTNIK-SPECIAL
SHORT-WAVE RECEIVER 10–60 MC/S (5-30 Metres) RECEPTION SET TYPE 208



Complete with 6 valves, 2 6K8G, 2 EF39, 6Q7G and 6V6G. Internal mains power pack and 6V vibrator pack. Built-in $6\frac{1}{2}$" speaker. Muirhead slow-motion drive. B.F.O. and R.F. stage. I.F. freq. 2 Mc/s. Provision for phones and muting and 600 ohms. **Input 110/250V a.c.** 6V vibra pack included for battery operation. All sets in new condition and air tested. **£6 . 19 . 6.** Carr. 15/6
BE PREPARED TO LISTEN TO THE SATELLITES

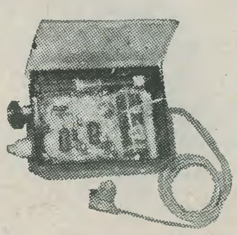
"EAVESDROPPER"
THREE-TRANSISTOR POCKET RADIO
(No Aerial or Earth required)



Medium wave. Variable tuning. Total cost, as specified, including Transistors, Transformers, Coils, Condensers and Battery, etc., with circuit and plastic case. All items sold separately **70/–** POST FREE. With single 'phone **73/6.** With Acos Mike, **82/6.** With Min. Hearing Aid, **86/–**

TRANSISTOR PUSH-PULL AUDIO AMPLIFIER
(200 Milliwatts Output)
Build this Push-Pull Amplifier which is ideal for Crystal or Magnetic Pick-up Amplification, Baby Alarm, Microphone Amplifier, etc. Powered by 6-volt dry battery lasting for months.
Complete kit of parts including four transistors and all components with circuit and plastic case (less Speaker) **69/6**

TRANSISTOR SIGNAL TRACER
Complete Kit with 2 Transistors, components, phones, with circuit and plastic case **37/6**

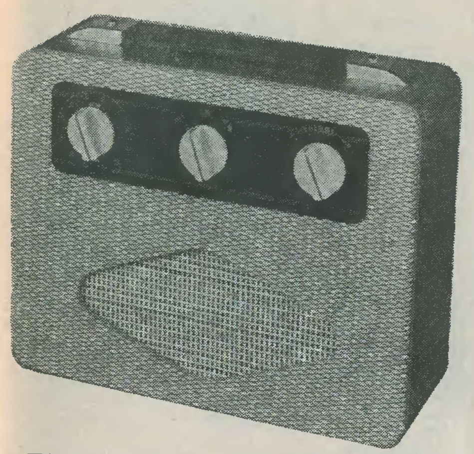


"HOMELIGHT" TWO TRANSISTOR PERSONAL PORTABLE
Variable tuning. We can supply all components, including two transistors, diode, resistors, condensers and miniature hearing aid and plastic case, size $4\frac{1}{4}$" x $2\frac{7}{8}$" x $1\frac{3}{8}$" and 3V battery for **50/–.** Practical layout

All items sold separately

"HOMELIGHT III"
As above, but with extra transistor stage, increasing output, complete with 3 transistors, etc. **58/6**

The "TRANSISTOR - 8"
Push-Pull Portable Superhet



This Portable 8-Transistor Superhet is tunable for both Medium and Long Waves and is comparable in performance to any equivalent Commercial Transistor Set. Simplified construction enables this set to be built easily and quickly into an attractive lightweight cabinet supplied.

COMBINED CAR RADIO & PORTABLE

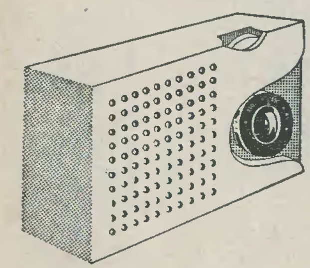
TWO SETS FOR PRICE OF ONE

TEN STAR FEATURES
- ★ 8 specially selected Transistors
- ★ 250 Milliwatts output push-pull
- ★ Medium and Long Waves
- ★ Internal Ferrite Rod Aerial
- ★ Highly sensitive
- ★ Drilled Chassis $8\frac{1}{2}$" x $2\frac{1}{2}$"
- ★ Point to point wiring and practical layout
- ★ Economical. Powered by $7\frac{1}{2}$V battery
- ★ Ideal as a car radio
- ★ Attractive lightweight contemporary case

All components as specified can be supplied at an inclusive price of
£11.10.0 p.p. 2/6
Car radio conversion components 8/– extra

N.B.—Pair of XC101's for larger output supplied at additional cost of **40/-** Call and hear demonstration model

MINI-7 POCKET TRANSISTOR PORTABLE



Size $5\frac{1}{8}$" x $2\frac{1}{8}$" x $2\frac{3}{4}$"

SPECIAL FEATURES
- ★ 7 selected transistors
- ★ Internal ferrite aerial
- ★ Operates from 6V battery
- ★ Practical layout
- ★ Drilled chassis
- ★ Long wave 10/6 extra
- ★ Attractive plastic case

ULTRA SENSITIVE!
ECONOMICAL!
HIGHLY SELECTIVE!

May be Built for **£9.19.6**

THIS SUPERHET IS SUPERIOR IN PERFORMANCE TO MOST COMMERCIAL TRANSISTOR SETS AND COSTS LESS THAN HALF THE PRICE

All components as specified can be supplied at an inclusive cost of £9.19.6 p.p. 2/6

Send 1/6 for Instruction Booklet and Prices

● WELL RECOMMENDED ●

HENRY'S RADIO LTD · 5 HARROW ROAD · LONDON W2
Telephone **PADdington 1008/9**

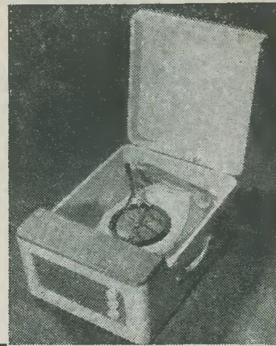
FULL DISCOUNTS ON TRANSISTORS AND COMPONENTS TO THE TRADE

CLEARANCE SALE

COMPLETE PLAYER

Consisting of Galaxy 4-speed changer in quality two-tone case excellent 3 valve amplifier, 7" spkr., beautiful reproduction (worth £20)

13 GUINEAS



4 SPEED STAAR GALAXY

RECORD PLAYERS as illustrated. Acos GP65 sapphire turnover pick-ups Plays 10 records of any size or speed through your radio. 200/250 volts a.c. **£5.15.0** (Post 4/-)

THE BARGAIN OF THE YEAR!

AUTOCHANGERS as above player but less case (Post 4/-) (Listed £12.16.0) **£3.19.6**

SIGNAL GENERATORS. B.S.R. LO50A L.F., 30c/s–18 kc/s, **£12.10.0.** Marconi TF390G in transit cases, **£12.10.0.** Marconi TF517F, 150–300 Mc/s, **£9.** All mains 200/250V.

AMPLIFIERS. Parmeko 200/250V a.c. mains, 10/20W complete EF36, ECC31, 2 EL35, 524, untested, **£3.15.0.** Quality 5 watt amplifiers 6J5, 6J7, 6V6, 5Z4, Parmeko mains and output trans., **£2.19.0.** Ardente 12V street broadcast 10/20W compact, 2 ECC31, 2 6L6, rotary convertor, **£4.10.0.** Ditto 24 volt **£3.15.0.**

TRANSMITTER/RECEIVERS. U.S.A. Collins TCS12. Transmitters 1625's modulating 1625's, Xtal or manual 1½–14 Mc/s, store soiled, **£6.10.0.** Receivers to match **£4.10.0** or **£10** per pair. U.S.A. TBS-9 Transmitters, 808's modulating 808's (about 10 valves), 100–150 Mc/s, **£7.10.0.** Receivers to match (about 10 valves), **£4.10.0**

POWER PACKS. 230V a.c. in., 2 separate double smoothed outputs of 375, 550 or 620V at 200/250mA, also 6.3V 5A. Sealed transit cases, 4 5U4G valves, **£7.10.0.** Less valves, **£6.10.0**

MAINS TRANSFORMERS, 230V in., 525–0–525V 150mA, 6.3V 5A, 5V 3A, **25/-.** Chokes to match, 150mA 6/-.

L.F. CHOKES. 10H, 80mA, **5/-**; 5H 250mA, **4/6**; 7H 250mA, **6/-**

RECTIFIERS. Iron selenium 3½A 12V bridge **9/-.** **£5** doz. 250V 80mA **5/-**; 250V 250mA, **12/6**

ION TRAPS, standard type, **4/-**

VALVE VOLTMETERS. Marconi, standard type. Measures from 0.1 to 150 volts, transit cases, **£9**

TV CABINETS. 14" table with mask glass, front 7" × 4" speaker fret, attractive, **25/-** carr. **4/-**

FOCUS MAGNETS, wide angle, with centreing and mounting, **9/6.** Ditto double magnet **12/6**

CONDENSERS. U.S.A. 0.1µF 350V metal tub., **6/-** doz. 16+16, 350V, small Dubilier, **3/-**; 100µF 6V, **1/3**; 100+200µF, 275V wkg, can, **5/6**; 0.001µF, 18kV Visconal, **4/6**

FLUTED KNOBS. 2½" instrument, large type for ¼" spindle, **1/-** each

COSSOR WOBBULATORS, all wave, **£9.10.0**

13 CHANNEL CONVERTORS. For T.R.F. or superhet receivers. Famous make. 3-position switch, fine tuner and 9 quick-set trimmers. Give any 3 channels, T.R.F. Band I, superhet Band III. Output direct to aerial socket. Beautiful bakelite case with PCC84, PCF80, **£3.15.0**

12 VOLT 3-4 AMP RECTIFIERS, 9/6 to **£5** doz.

GUARANTEED TV TUBES (Ex Equipment) 12" (MW31-74, 3/31, etc.), **£5.5.0;** 14" (MW36-24, 4/14, etc.), **£4.10.0;** 17" (MW43-64, 4/15, etc.), **£6.10.0;** 17" (CRM171 only), **£6.** (All guaranteed 6 months) (carr. and ins. 12/6)

GERMANIUM CRYSTAL DIODES, famous make, tested, **9d.,** p. and p. 3d., **8/-** doz.

TRANSISTORS. Red Spot (up to 800 kc/s), guaranteed, **7/-**; White Spot (up to 2.5 Mc/s) guaranteed, **14/-**

GUARANTEED RADIO VALVES, BOXED,
24 HOUR SERVICE

5U4G	6/6	6SN7GT	5/9	EBC33	7/-	EZ40	8/-
5Z4	9/-	6U4GT	12/6	EC52	5/-	EZ80	7/6
6AC7	5/-	6V6G	6/-	ECC31	9/6	HVR2A	5/-
6A8	9/-	6V6GT	6/6	ECC32	9/-	KTW63	6/-
6AL5	5/6	6V6M	7/-	ECC81	8/-	MU14	9/-
6AM6	7/-	6X4	6/-	ECC82	6/6	P61	2/6
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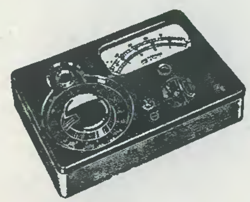

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