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VOLUME 11
NUMBER 7
FEBRUARY
1958

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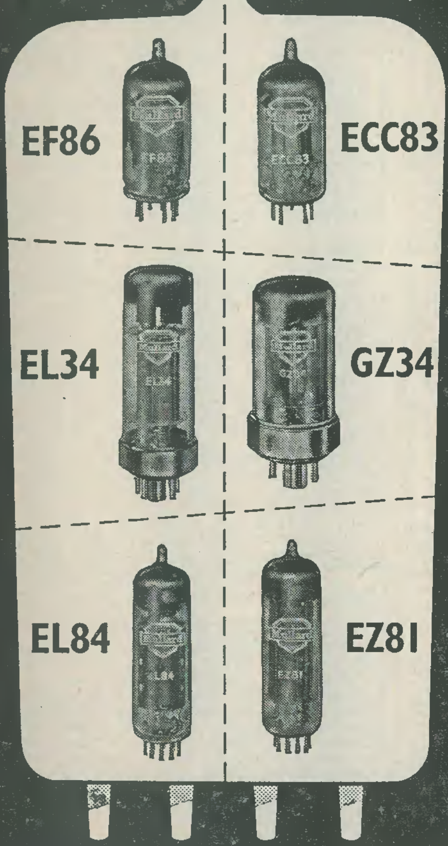

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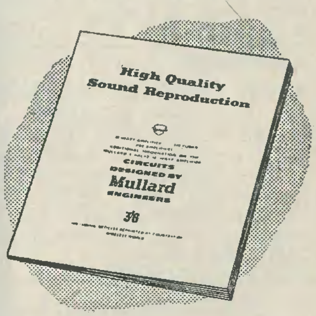

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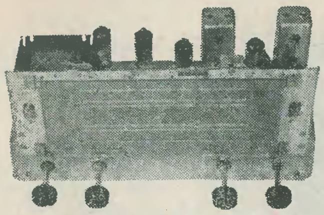

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6J5	6/6	12Q7	8/6	EF92	5/6	UF41	10/6
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6J7	8/6	80	8/6	EL84	10/6	UY41	10/6
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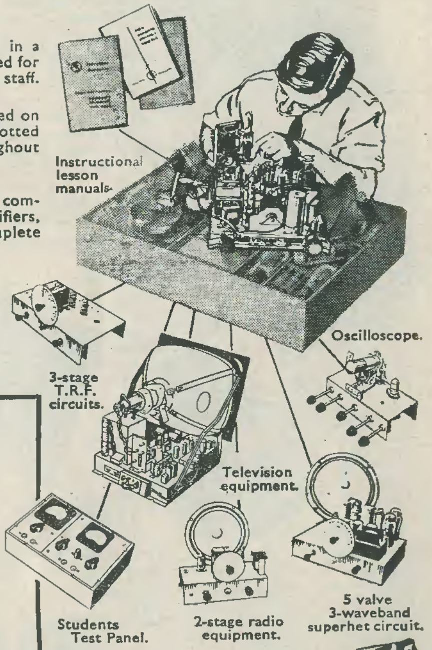

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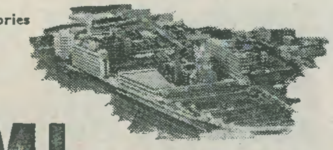

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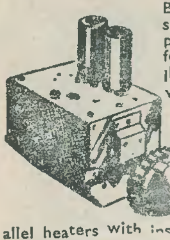

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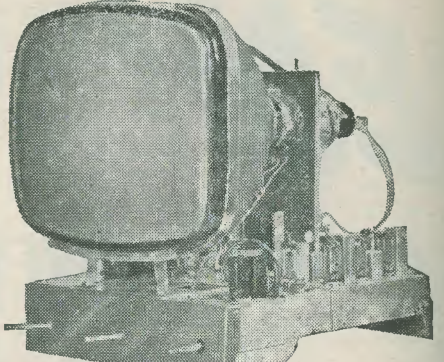

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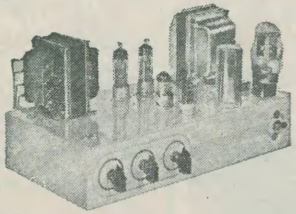

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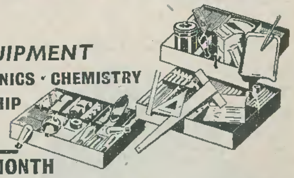

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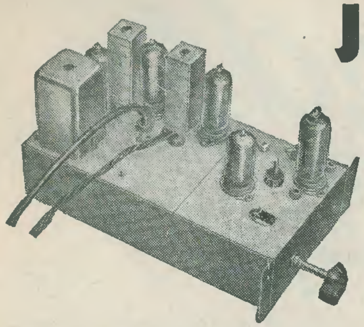

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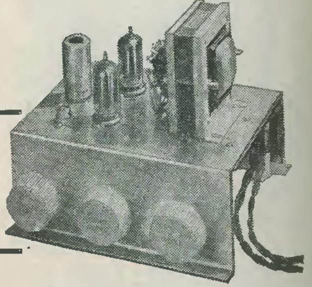

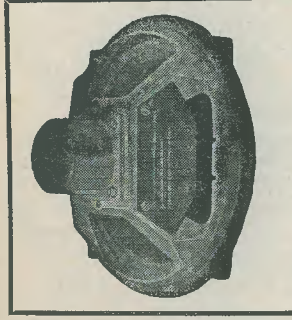

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Heater current	0.4 amp
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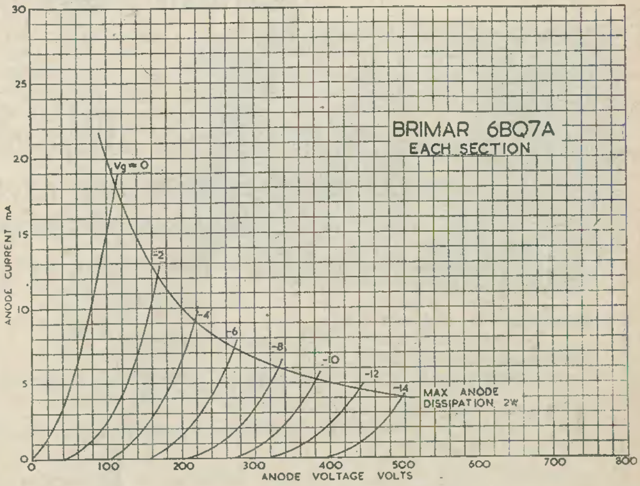
Cathode bias resistor	220 ohms
Anode current	9mA
Mutual conductance	6.4mA/V
Amplification factor	39
Anode resistance	6,100 ohms
Grid cut-off voltage (I_a—10μA)	—10 volts approx.



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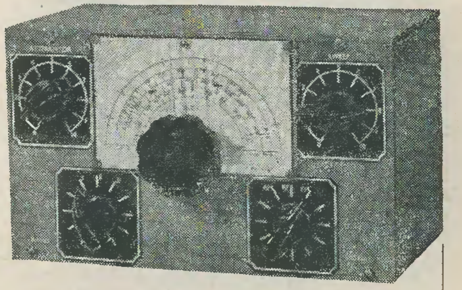

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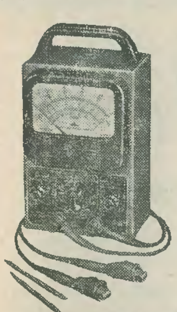

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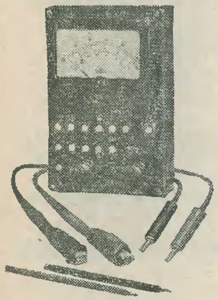

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No. 87. A SIMPLE AND RELIABLE A.C. VALVE VOLTMETER

FROM TIME TO TIME, IN SERVICING AND experimental work, it becomes necessary to measure a.c. voltages at frequencies which may vary from 50 c/s to some 50 Mc/s or so. An instrument which is very frequently employed for reading such voltages is the a.c. valve voltmeter, this normally consisting of a simple diode probe followed by a bridge voltmeter.

This Month's Circuit

A circuit arrangement of this type is employed in the a.c. voltmeter which forms the subject of this month's article. Some care has been taken to ensure that the design lends itself to simple and reasonably inexpensive construction, without sacrificing the features of long-term accuracy and freedom from drift. In order to obviate the necessity of obtaining very close tolerance components it is recommended that the instrument be calibrated against a conventional moving-coil testmeter after completion. The process of calibration may consist of either fitting a new scale to the meter movement in the instrument, or of adjusting resistor values such that the existing scale may be read directly. (The first alternative will be necessary on the lowest voltage range in any event, as readings here will be non-linear). Calibration can be carried out quite reliably at 50 c/s, with the consequence that the process should not incur any great practical difficulties.

The circuit of the a.c. valve voltmeter appears in Fig. 1, and it will be seen that in many respects it follows conventional practice. The diode V_1 is the probe detector, and functions as a shunt rectifier. The time constant of R_1 and C_1 (10MΩ and 0.02μF) is 0.2 second, with the result that true peak voltages should appear across R_1 for input frequencies down to some 25 c/s or so. The rectified d.c. voltage appearing at the anode of V_1 is applied via R_2 to the grid of $V_{2(a)}$, this triode forming half of the balanced voltmeter arrangement. In order to overcome the errors introduced on low voltage ranges by contact potential in V_1, a second and similar diode, V_3, is connected, in an equivalent circuit, to the grid of $V_{2(b)}$. Special precautions are taken in the instrument to ensure that V_1 and V_3 balance each other accurately,

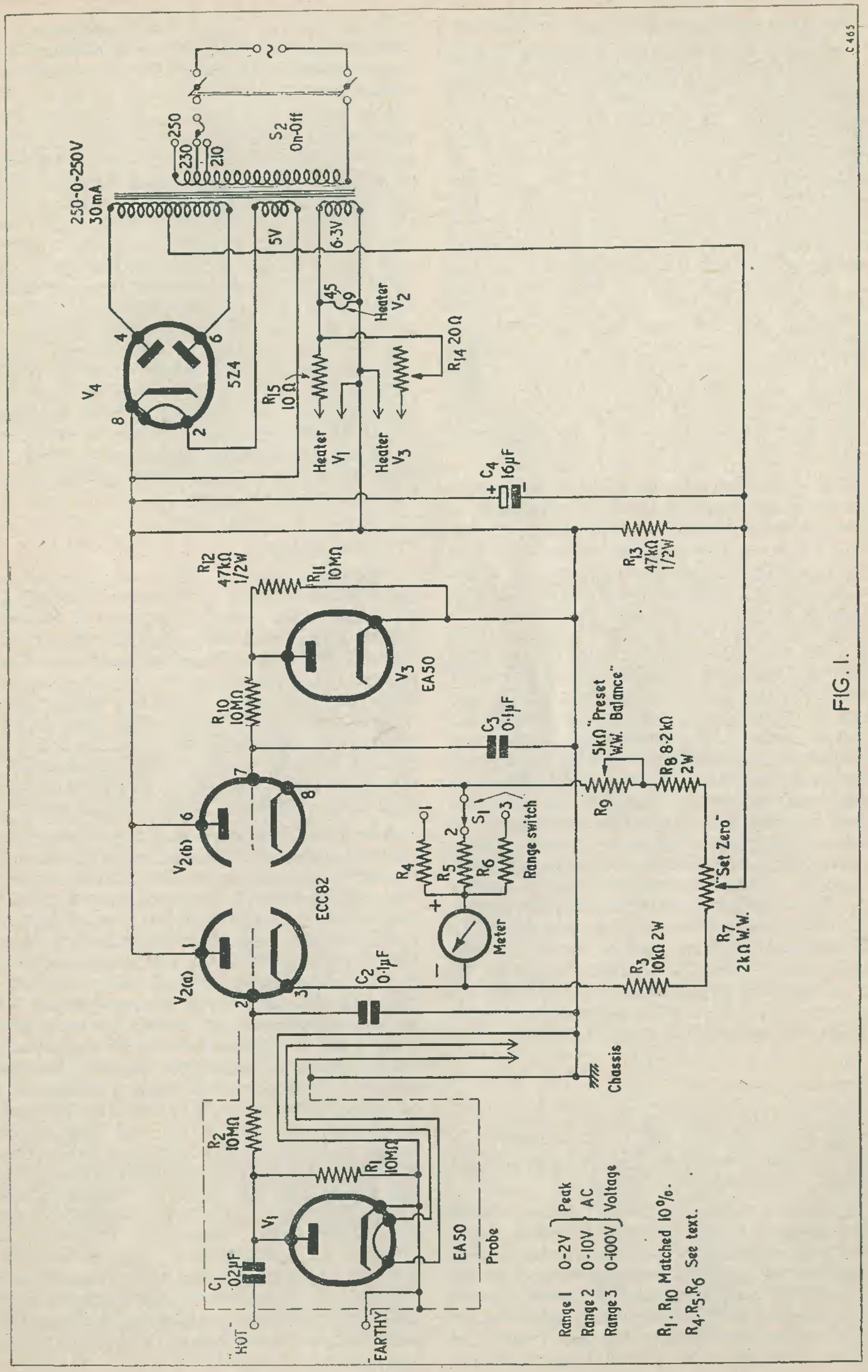


FIG. 1.

these being dealt with in greater detail later.

$V_{2(a)}$ and $V_{2(b)}$ function as cathode followers, thereby causing a potential difference to appear between their cathodes which is very nearly equal to the potential by which the grid of $V_{2(a)}$ is negative to the grid of $V_{2(b)}$. The potential difference at the cathodes is measured by the milliammeter M_1, different ranges being selected by the switch S_1. The presence of the milliammeter (together with its series resistors) causes the potential difference between the cathodes of $V_{2(a)}$ and $V_{2(b)}$ to be slightly less than would be the case if it were omitted, but this point may easily be taken care of when the instrument is calibrated. The pre-set control R_9 is inserted in the circuit to allow unbalance in the cathode load resistors to be taken up; whilst the panel Set Zero control R_7 provides short-term adjustments when the instrument is in use.

It is important to note that the h.t. supply for the instrument does *not* have its negative line connected to chassis. The reason for this is that it is necessary to relate the earthy side of the source of voltage being measured to the cathode of V_1, with the result that the grid of $V_{2(b)}$ takes up the negative potential below chassis provided by the rectified voltage from V_1. In practice this feature need cause little difficulty, the only probable source of trouble being low leakage resistance between the h.t. and l.t. secondaries of the mains transformer and chassis. The insulation resistances between these windings and chassis do not, incidentally, have to be excessively high; they need only be high enough for the relatively "low impedance" bridge circuit around V_2 to operate satisfactorily. Any good quality impregnated transformer should cope satisfactorily in the instrument. It is worth pointing out that a valve rectifier rather than, say, a contact-cooled rectifier, is specified in the circuit, this being mainly due to the ease with which such a component may be reliably isolated from chassis. If the electrolytic condenser C_4 has a metal case this should, of course, be insulated from chassis.

Contact Potential

As was stated above, special precautions have been taken in the valve voltmeter to balance out the errors given by the contact potential of the probe diode V_1.

Contact potential in a diode whose anode and cathode are connected together via a relatively high resistance exhibits itself as a negative voltage at its anode relative to its cathode. This voltage may frequently be of the order of half a volt, and is sufficient to affect the reliable functioning of a valve voltmeter intended for low-voltage measurements. In the circuit discussed here the contact potential given by V_1 is balanced by that from an equivalent diode (V_3) connected in an equivalent circuit.

Unfortunately, contact potential, even between two apparently equivalent diodes, is liable to vary according to several factors, prominent amongst these being the amount of gas in either diode, the electrode spacing, and the cathode temperature. The first two factors, gas and electrode spacing, might, perhaps, be balanced out by employing in the V_1 and V_3 positions two diodes from the same manufacturing batch; but the reader is not advised to go to the trouble and expense of meeting this particular requirement. The third factor, cathode temperature, is fairly easy to control, such control being given by adjusting the heater voltage of either diode. An adjustment of heater voltage is provided in the circuit described here, and the method with which it is employed is described in the last section of this article.

Practical Points

Although no very close tolerance components are required in the valve voltmeter it is necessary for a certain amount of experimental adjustment to be carried out on R_4, R_5 and R_6 during final calibration. (The process of "adjustment" may consist of shunting high-value resistors across any resistor whose value is too high, and so on. Alternative methods, such as setting up circuits initially with variable resistors and replacing these with fixed equivalents may commend themselves to the constructor.)

A 0–1 milliammeter would give excellent results in the M_1 position, the writer having primarily in mind an ex-Government movement whose scale is calibrated from 0 to 100. With such a meter the 0–100 volt range will require a value in R_6 of slightly less than 100kΩ and, on the 0–10 volt range a value in R_5 of slightly less than 10kΩ. As has already been stated, these two ranges should be linear enough (or, at worst, linear above 1 volt) for the milliammeter scale calibration to be directly employed should this be desired. On the 0–2 volt range a value in R_4 of slightly less than 2kΩ will be required. This particular range will not give linear results so far as any existing meter calibration is concerned, and it will be necessary to check meter readings at different voltage levels within the range. It should, incidentally, be remembered that the valve voltmeter is intended to be calibrated in terms of peak voltage, whilst any moving coil testmeter used for calibration purposes will have a scale calibrated in r.m.s. voltage. (Assuming a sine wave, peak voltage is 1.414 times r.m.s. voltage.)

The mains transformer shown in the diagram has a centre-tapped h.t. secondary. A possible alternative, which might incur less cost, could be given by a transformer having a single phase secondary winding, this being employed in a half-wave circuit with the two anodes of V_4 strapped. If a half-wave circuit is employed, it would be advisable to insert a limiter resistor of some 150Ω between the cathode of the rectifier and C_4 to limit ripple current. Any other similar type of valve rectifier may be employed in place of the 5Z4 specified. Although the cathode follower action in the valve voltmeter renders the need for a stabilised h.t. supply largely superfluous, it is still desirable to employ a mains transformer whose primary may be adjusted in 20 volt steps to suit the supply voltage available. A transformer with an untapped "230-volt" primary should not be used.

The valve V_2 forms an important part of the circuit and, to ensure good balance, it is advisable to employ a double triode in this position which has not seen any previous arduous service.

Setting Up

After completion, the valve voltmeter should be set up in the following manner.

The instrument should primarily be switched on and allowed to warm up for some five to ten minutes. The "hot" and "earthy" terminals of the probe should next be short-circuited together and S_1 set to range 1. (A resistor which would cause an f.s.d. reading corresponding only approximately to 2 volts may be employed in the R_4 position during setting up, when this process is carried out immediately after construction.) The first component to deal with is the pre-set control R_9. To enable this control to be adjusted, the panel Set Zero control, R_7, should be set to the centre of its track and the grids of $V_{2(a)}$ and $V_{2(b)}$ temporarily connected together; whereupon R_9 is adjusted until the meter gives a zero reading. It should then be possible to cause the meter to swing on either side of zero by moving R_7 to either side of its central position. R_7 should, finally, be returned again to the position which gives a zero reading.

The procedure just described ensures that any unbalance in the cathode potentials of $V_{2(a)}$ and $V_{2(b)}$ are cancelled out when the grids of these two valves have the same potential.

The temporary link between the two grids of the double triode is next removed, thereby causing these grids to become controlled by the contact potentials on V_1 and V_3. *Without moving R_7 from the central zero setting previously obtained*, R_{14} should next be adjusted until the meter once more gives a zero reading. Adjusting R_{14} varies the heater voltage of V_3 and it should be borne in mind that it will be necessary for the cathode of this diode to attain its altered temperature before the result of any adjustment becomes fully apparent. Several experimental adjustments in R_{14} will be necessary before a final zero reading is obtained, and it would be advisable to allow some thirty seconds to elapse between these adjustments. It may be helpful to note that, if the meter gives a reading which is positive of zero, this infers that the contact potential given by V_3 is lower (less negative) than that given by V_1. R_{14}, in consequence, should be set to insert less resistance into circuit to overcome this. Similarly, a meter reading which is negative of zero may be corrected by having R_{14} insert more resistance into circuit. As, in some cases, it may be difficult to find a final setting of R_{14} which gives an exact zero reading, it would be permissible to work with one which enabled a zero reading to be obtained after only a *slight* readjustment of R_7.

In common with other instruments of this type, slight drifts will occur after setting up if V_1 or V_3 are new, or have not been used for several months. When such is the case it would be advisable to finally check the setting of R_{14} after the valve voltmeter has been switched on for some four or five hours.

After setting up is completed, the temporary link between the probe terminals should be removed, whereupon the instrument is ready for use or, if construction has only just been completed, for initial calibration. Little needs to be stated about the procedure for taking measurements, as this is fairly obvious. However, it may be worth pointing out that greatest accuracy will be given when a low d.c. resistance exists between the two points across which a voltage is being measured. (Such conditions would be given if the probe terminals were connected, for instance, across a coil or winding). If a careful layout has been adopted in the probe, input capacity should not be very much greater than the C_{ak} (2.1pF) of the diode itself.

Before a series of readings are taken, the Set Zero Control should always be adjusted with the probe terminals short-circuited together and S_1 set to range 1. The setting of R_7 thereby obtained will automatically hold good for ranges 2 and 3. If, after a period of use, it is found that R_7 has to be adjusted close to one end of its track, it would be advisable to repeat the setting up procedure detailed above. However, this state of affairs will probably only occur if new diodes were employed when the valve voltmeter was initially assembled.

SERVICING

IN YOUR WORKSHOP

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

If anyone were to ask Smithy whether he thought that his assistant Dick performed a useful service in the Workshop, the Serviceman would probably have admitted (albeit a little reluctantly) that this was true. In actual fact, since Dick had commenced working with Smithy, the Workshop had been able to handle some 50 to 70 per cent more work than had previously been possible, and Smithy was well aware of this. Also on the personal side, Smithy liked Dick's keenness and adaptability as well as his seldom-dormant sense of humour.

Despite the fact that Smithy appreciated Dick's company during the day, he was human enough to become somewhat irritated now and again by some of Dick's habits. Apart from his continual questions (which Smithy realised were necessary if his assistant were to learn his trade fully) Dick appeared, especially, to have an inherent inability to recognise that loud, discordant, noises could be a source of considerable annoyance to others. If, for instance, Dick was repairing a sound receiver which suffered from distortion, he would be perfectly happy to prod his way through the chassis whilst the volume control was turned to its maximum position; and would be blissfully unaware that Smithy, trying to concentrate on his own servicing problem, was undergoing tortures in consequence.

On one particular winter's morning Smithy's desire for a quiet life was subjected, by Dick's contribution to the business of the Workshop, to a strain which was more excessive than usual. Dick's first job that morning had consisted of curing a televisor which suffered from sound-on-vision. Dick carried out the routine check of ascertaining whether the sound-on-vision disappeared when the volume control was turned down. It did (thereby exonerating the vision i.f. strip sound rejector circuits), and a certain amount of valve tapping revealed that the PCF80 mixer in the turret tuner had become microphonic. A replacement valve cleared the trouble, but not before Dick had spent some fifteen minutes filling the air of the Workshop with continual music dispersed from a cubic cabinet enclosing a 2½-watt output valve trying to feed 3½ watts into a four-inch speaker.

Instability

Smithy's incipient ulcer relaxed as Dick returned the faulty televisor to the rack, but the subsequent period of quiet was short-lived. Dick's next job consisted of a record player with an intermittent fault. The complaint was that the output of the record-player was thin and reedy, except on loud passages, whereupon it suddenly "cut-in" and functioned with its normal tone and volume.

When Dick had first joined the Workshop he had been a little disappointed at Smithy's small stock of test records, and had added a few of his own choice. During the repair of the faulty record-player, therefore, Smithy was regaled with Stan Kenton under intermittently quiet and very loud conditions. Whilst the Serviceman tried to apply himself to his work, Dick happily checked cathode potentials in the record-player amplifier. There were no significant changes in these potentials between the condition when the amplifier was functioning correctly and when it was giving its high-pitched output, and Dick next proceeded to check the a.f. coupling condensers. His first choice, the condenser coupling the previous anode to the grid of the output valve, proved to be the seat of the trouble; this component presumably being open-circuit except when a high level of a.f. caused its intermittent connection to be made "good." Dick's replacement condenser brought the record-player back to full working order and a final triumphant test run ("All Shook Up"—Elvis Presley) brought an appreciative grin to Dick's face and hastened the addition of several more grey hairs to Smithy's thinning crop.

Elvis Presley finally got into the centre groove of Dick's record, and the shaken-up Smithy breathed a silent sigh of thanks when Dick returned the record-player to the shelf. His sense of relief was once again short-lived, however, because Dick's next job consisted of another television receiver, this particular model suffering from unstable sound. After only the time that it takes for a valve to warm up, the quiet of the Workshop was shattered by piercing heterodynes as Dick turned the fine tuner through its central position. Smithy decided that he had had enough.

"For the love of mike," he yelled, against the racket, "turn that blessed set down! I'm just about going round the twist!"

Dick looked surprised and a little injured, but he reduced the volume on his receiver at once.

"I'm sorry if I've been kicking up a din, Smithy," he remarked; "I just hadn't realised I was making so much noise. I suppose I *did* have the other two jobs running a little loudly, but you must admit that they had to go all out now and again if I was ever to find the faults in them."

"That's fair enough," replied Smithy, mollified. "Anyway, on the set you're doing now you don't need to turn the volume up unless the instability is getting back from the a.f. stages."

He walked over and adjusted the fine tuner on the faulty receiver and noticed that, even at a low volume, a heterodyne whistle was heard beating with the sound channel of the transmitter to which the set was adjusted.

"Well, it seems to be a straightforward case of i.f. instability," he decided after a moment. "There is no squegging or hissing noise, which might make one think that the unwanted feedback loop included the a.f. stages as well as the i.f. stages. Incidentally, instability in the i.f. stages *only* can sometimes give a hissing or squegging sound. However, in this case the heterodyne still continues, and with virtually no change of note, even when you turn the volume control to the barely audible position; and so I would say that the a.f. stages are almost certain to be outside the feedback loop. You've probably got an i.f. stage oscillating away happily by itself, and it should not take too long to discover the trouble."

"Is it worth swopping bottles first?" asked Dick.

"Well, it's nearly always advisable to check valves," remarked Smithy, "even when, as in this case, it is rather doubtful that they are causing the trouble. One of the most expensive factors in servicing is time, and I think it's worth changing a valve even when it is improbable that it is the guilty factor. After all is said and done, it would be silly to spend hours looking for a snag when it is just possible that a two-minute test will clear the trouble. Incidentally, you have to be rather careful when changing valves in an unstable i.f. strip. It is quite feasible for the detuning given by a new valve to move the tuned circuits sufficiently off resonance for the instability to clear. The instability might then re-appear after the customer had had his set back for a month or so. Ideally, you should always re-align the stages on either side of new valves fitted to t.v. i.f. strips. I appreciate that this isn't often done in practice, but the process would at least confirm that a new valve had really cleared the instability."

"O.K." said Dick. "In this case re-alignment shouldn't take up too much time since, as the fault occurs on the sound i.f. strip, all the coils are almost certain to peak at the sound i.f."

"Just as you like," said Smithy. "Nevertheless, I should check the service manual before you touch any cores. It's most likely that your instability is caused by a faulty decoupling condenser."

Sound I.F. Strips

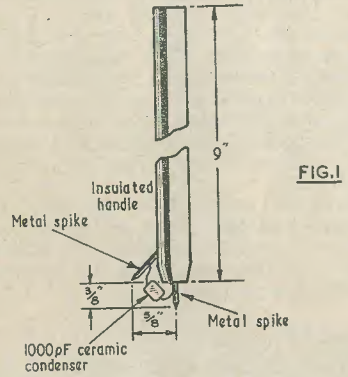
Smithy returned to his own bench, leaving Dick to carry on with his unstable receiver. Quiet descended upon the Workshop and Smithy luxuriated in it. He soon became engrossed in his own work, and he was suddenly surprised to note that over an hour had passed since he had spoken to Dick, and that a cup of tea was more than overdue. Normally, it was one of Dick's duties to prepare the tea for their morning break, but when Smithy looked over, his assistant was so deeply buried in his receiver that the Serviceman decided to let him be. When, some five minutes later, he called Dick over for his "cuppa," his assistant also looked startled at the passage of time, Resignedly laying a screwdriver on the bench, he wandered to the battered tea-tray which did service in the Workshop, a heavy frown on his face.

"Well, I've certainly picked a stinker this time!" he remarked, after a few sips at his cup. "The instability in that set is here to stay."

"Not to worry," said Smithy soothingly. "You can't always pick easy jobs."

Dick poured himself a second cup of tea. "Tell me," he said, after a few moments, "just how *you* would have tackled the job, and let's see if I've done it in the same way."

"O.K." said Smithy, "but first of all, I think it is worth mentioning that instability in sound i.f. strips is sometimes one of the most difficult things of all to put right. One of the reasons for this is that, due to the very nature of the instability itself, you often find it difficult to pin-point the place where the fault is occurring. Once the strip goes unstable, *everything* within the unwanted feedback loop commences oscillating, and you can easily be deceived into following false trails. Another reason for the difficulty of tracking down instability in a sound i.f. strip is that this section of the set is normally expected to provide a very high degree of i.f. gain at a single spot frequency; with the result that, since it is economical to use as few stages as possible, each valve has to give considerable amplification whilst having undamped, high-Q, tuned circuits connected to its grid and anode. Some sets use sound i.f. valves having quite high values of g_m, and the risk of anode-to-grid feedback causing instability becomes even worse. Also, don't forget that sound i.f. strips these days use the relatively high frequency of 38.15 Mc/s.



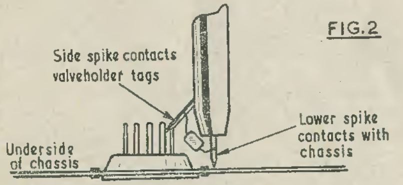


Fig. 1. A simple decoupling condenser tester for use on t.v. i.f. strips. The metal spikes could consist of 6-BA bolts filed to points. Dimensions are approximate only.

Fig. 2. The tester in use. By means of the spikes the condenser on the tester may shunt a suspect decoupling condenser. It should be noted that the test condenser is applied via a short conducting path, and with reliable connections

"Anyway, let's get back to your question: what would I have done if I had been confronted with your unstable sound i.f. strip? Well, as I said earlier, I would first of all have tried new valves, just on the off-chance that they might clear the snag."

"I did that," replied Dick. "No luck!"

"Which we didn't really expect in any case," Smithy returned. "The next thing I would have done would be to give the strip a quick superficial examination to make certain that something 'silly' hadn't happened. I would check visually to ensure that all decoupling condenser joints were O.K., and so on. Just a straightforward quick examination for something obvious."

"I did that as well," said Dick, "but everything was perfectly ship-shape."

"Did you check that the centre spigots of each valveholder were correctly earthed?"

"I did," replied Dick, "but there was nothing wrong there at all."

"Fair enough," said Smithy, stroking his chin reflectively. "From now on, we're service engineers! Although it may not sound entirely logical, I *think* that the next thing I would do would be to check valve potentials on anode, screen, cathode and grid. It might be *just* possible that a valve was working with incorrect potentials. However, what is just as important is that, by prodding the various points, you might be lucky enough to find the root of the trouble."

"Well, I made voltage checks," said Dick. "But I found nothing out of the ordinary. By the way, the i.f. strip has two stages, and I found that prodding the grid of the first valve caused the note of the heterodyne to change, whilst prodding the grid of the second valve caused no difference."

"By which," commented Smithy, "you could form the opinion that it is probable that the feedback loop is in the first stage or is over the two stages. Not very helpful, really, I'm afraid.

"The next thing I would do would be to quickly check the decoupling of the h.t. line around the strip by applying, first, an 8 or 16μF electrolytic with shortish leads between the h.t. line and chassis at the sound i.f. section and, secondly, a 0.01μF, or thereabouts, paper condenser at the same points."

"As a matter of fact I tried that also," said Dick. "But it didn't do anything to the instability."

"Right," said Smithy. "The next things to attack are the individual decoupling condensers around each valve. How did you get on there?"

"Well," replied Dick, "I started off on this line of approach, but I'd only managed to check several condensers before tea came up. The trouble here is that it takes so long to check decoupling condensers which work at these high frequencies."

Smithy's Decoupler Tester

"I see your point," conceded Smithy. "When, in the old days, broadcast receivers went unstable it was a piece of cake to go round the decoupling condensers, bridging each one with a 0.01μF test condenser, to see if they were open-circuit. At the frequencies involved, it didn't matter much if there was an extra inch or two in the test condenser leads, and you could hold its body quite easily between finger and thumb. Unfortunately, at 30-odd Mc/s you can't go around shunting decouplers by a test condenser as simply as that. In the first place, all the decouplers have to be connected to their circuit points by very short leads, and in the second place you just can't reliably apply a tiny ceramic condenser with its flimsy leads to the two points you want it to bridge."

Smithy stopped for a moment.

"Or could you?" he continued thoughtfully.

Dick looked at the Serviceman with interest. After a few moments, Smithy pulled over a sheet of paper and commenced to draw on it.

"Dick," he remarked, "I've just had a minor brainwave. There's nothing to stop us knocking up a simple little device which will enable us to check decouplers on t.v. i.f. strips as easily as we used to do with sound receivers.

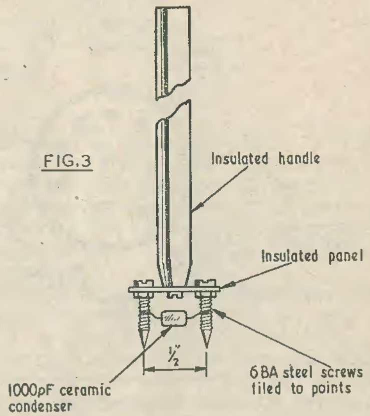
"I'm just making up a sketch showing how simple a t.v. i.f. decoupler-checking device could be made (Fig. 1). We first of all require a round handle some nine inches long, which is made of insulating material. At the bottom of the handle we fit a short metal spike. This could consist of a 6-BA steel bolt inserted into a tapped hole in the bottom of the handle, and filed to a point. Also secured to the rod is a second spike, which can consist of a filed 6-BA screw fitted in the same way as the first, this projecting sideways. We next solder a 1,000pF ceramic condenser across the two spikes using very short connections. And that's all there is to it!"

"How do you use it?" asked Dick, a little mystified.

"Simplicity itself," replied Smithy. "Decoupling condensers are almost always fitted between chassis and valveholder, or coil, tags. You first of all apply the bottom spike to the chassis of the receiver, digging it in a little to ensure that you are making good contact. You then rotate the handle until the spike at the side presses against the tag you want to connect your test condenser to (Fig. 2). The lead length, including the spikes, to the test condenser will be very short, and should provide a reliable decoupling path. When the test condenser is connected across an open-circuit decoupling condenser, then the instability caused by the latter will clear and you will have found your fault. Now, why on earth didn't I think of this idea before?"

Dick chuckled.

"Well, I think the best thing I can do now is to knock up a gadget like that before I return to my fault. It shouldn't take more than half an hour or so to make."



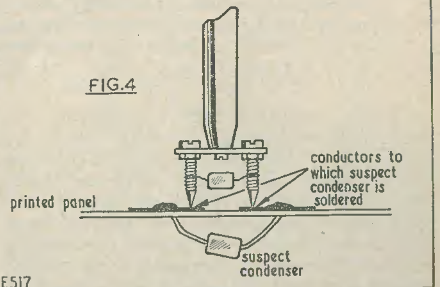


Fig. 3. Smithy's Mark II tester, for use on printed boards. The half-inch spacing between spikes should cope with most boards encountered. Fig. 4. The Mark II tester in use. The spikes are applied to the appropriate conductor areas, gentle pressure on the handle ensuring good contact.

Dick soon constructed a device similar to that described by Smithy, and applied it to his faulty receiver. When he bridged the fourth condenser he tried, the instability disappeared. He then fitted a new condenser in place of the faulty component, whereupon the fault cleared permanently.

Printed Circuit Tester

After Dick had completed his receiver and returned it to the "Repaired" rack, he was surprised to note that Smithy was engaged in assembling a device very similar to that he had just made himself.

"Hello," remarked Dick. "Don't say you've got instability too! Or is this another brainwave?"

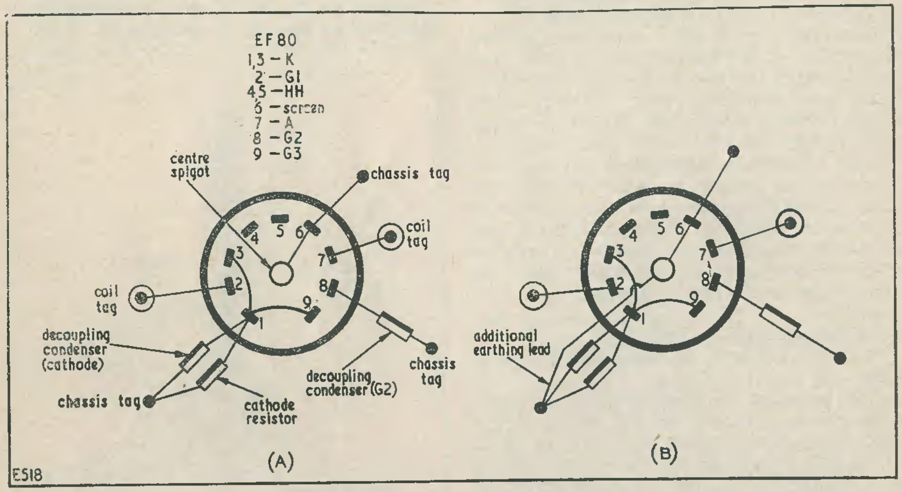


Fig. 5. An EF80 sound i.f. amplifier stage employing the layout shown in (a) was found to contribute to instability which could not be cleared by component replacement. By fitting an additional wire, making the earth lead straddle the valveholder as in (b), the amplifier was made completely stable

"This," replied Smithy impressively, "is our t.v. decoupler tester Mark II! When it's finished it will look like this (Fig. 3). As you can see, both of the test condenser spikes point downwards, and they are spaced from each other by approximately half an inch. This particular tester is intended for bridging suspect decoupling condensers on printed circuits and, from the experience I've had with these to date, I would think that half-inch spike spacing should cope for most boards. Since testers like this are so easy to make, there's no reason in any case why we couldn't knock up others, with different spacing, whenever they were required.

"To use the Mark II tester you simply apply the two spikes to the conductor areas to which the suspect condenser is connected (Fig. 4). A little gentle pressure should then ensure that you make contact through any varnish, etc., which might be coating the board."

"This is certainly a day for bright ideas," commented Dick.

"It does seem a little that way," replied Smithy. "By the way, did I see you put that faulty t.v. back on the shelf?"

"Yes," said Dick, "it's all fixed up now. The condenser decoupling the screen-grid of the first i.f. amplifier was faulty."

"Which is a likely component for a snag of that nature," Smithy commented. "Before finishing on this subject I think I would like to make one or two further points concerning sound i.f. strips.

"The first of these is that instability can sometimes be caused by faulty decoupling in the heater line. Many people look upon heater line decoupling as something of a 'text-book extra,' this probably being due to the fact that, in the past, they have removed heater decouplers without causing the slightest atom of difference to the performance of the set. In modern high-gain strips working at 38.15 Mc/s the heater decouplers sometimes become extremely essential components, and it is necessary to pay much more attention to them than may have been the case several years ago.

(*continued on page* 485)

UNDERSTANDING TELEVISION

PART 2

By **W. G. MORLEY**

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

In the first of these articles, published in last month's issue, we discussed the basic manner in which television pictures are transmitted and reproduced; and we also introduced and defined a number of terms which are employed extensively in this particular field of engineering. The means by which a picture may be built up using an interlaced scanning system was also outlined.

The Transmitted Signal

Having proceeded thus far, it next becomes necessary to study the signal radiated from the television transmitter in more detail. In order to do this we must concern ourselves with two important points.

The first of these is: what exactly do we need to put into the transmitted television signal so that we may reproduce a scene remotely? A glance at Fig. 6 may help us to answer this query. Fig. 6 (*a*) illustrates a very simple picture which we wish to transmit, and which consists of the word Oxo printed in black against a background of white. As we already know from the last article, our television camera examines the scene presented to it by a system wherein the scene is focused on to a plate. An electron beam is also focused on to the plate, appearing on its surface in the form of a spot. The electron beam is deflected from left to right and, slowly, from top to bottom. The scanning spot thereby traces out a number of horizontal lines, each positioned slightly below its predecessor. A similar pattern is traced out on a cathode ray tube at the receiver, with the difference that the electron beam falls on and activates a fluorescent screen. The strength of the cathode ray tube beam and, hence, the brightness of the spot on the screen, is varied in proportion to the output of the camera at the transmitter.

Let us see what happens when the television camera examines that part of the scene of Fig. 6 (*a*) which lies along the line AB. The spot in the camera starts from the left at point A and, in travelling along the line, traverses the white section until it encounters the left-hand edge of the first letter O. At this point the white of the scene changes immediately to black. Shortly afterwards a further white section appears, this being followed by another black section, and so on until the end of the line.

If we were to use the method of transmission employed in Britain at present, the output of the transmitter could look something like that shown in Fig. 6 (*b*). When we commence to scan our line we first encounter the white area. This corresponds in Fig. 6 (*b*) to maximum output from the transmitter. When we reach the left-hand edge of the first letter O the signal changes from white to black, and the transmitter output drops to what is described in Fig. 6 (*b*) as "minimum" output. As soon as we enter the white section inside the first O our signal returns to white once more, and the transmitter delivers maximum output again. And so the process continues until we reach the end of

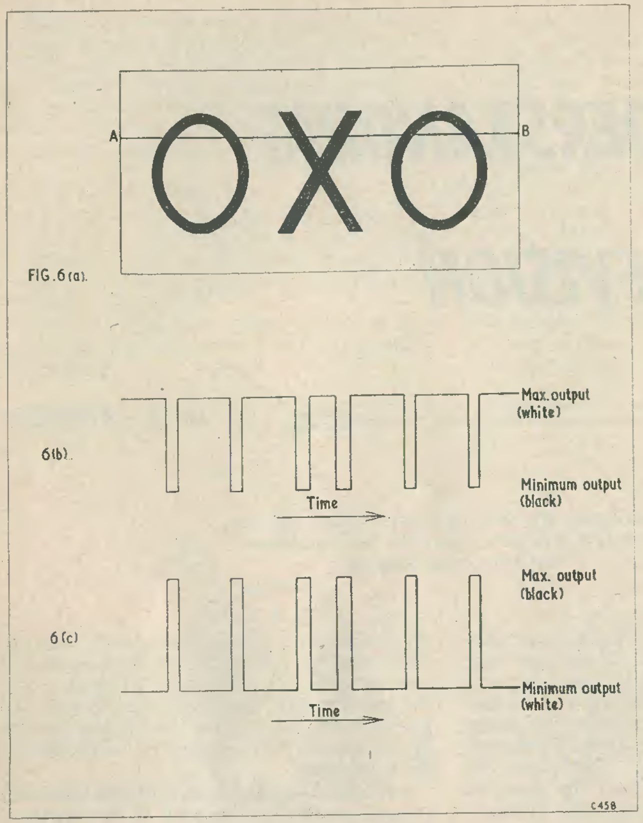


Fig. 6 (a). A simple black and white scene, of which line AB is being scanned. (b) The output given by the television transmitter when a positive modulation system is employed. (c) With negative modulation systems, maximum transmitter output corresponds to black

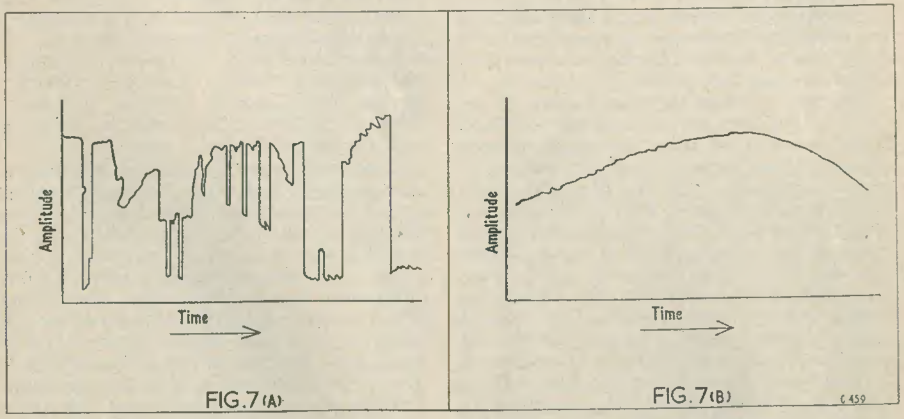


FIG.7(A) FIG.7(B)

Fig. 7 (a). The signal sent during a line of a normal television transmission may frequently have a very considerable amount of detail. (b) It is conventional to illustrate a line of a picture by the simple waveform shown here

the line, the transmitter output being at maximum for white and at minimum for black. There were no grey sections in the scene to be transmitted, but, had there been any, these would have been represented by a transmitter output lying between maximum and minimum according to the brightness or darkness of the grey.

The waveform shown in Fig. 6 (*b*) represents what occurs when *positive modulation* is used. A television system employs positive modulation when maximum transmitter output corresponds to a white signal. This method of modulation has certain disadvantages which were not foreseen when the British television service was set up in 1936, and later television systems employ *negative modulation*. With a negative modulation system maximum transmitter output corresponds to a *black* signal, and the sample waveform shown in Fig. 6 (*c*) illustrates how the line AB of Fig. 6 (*a*) would be transmitted under such a system. As may be seen, all that happens is that the *sense* of the modulation is reversed.

Apart from captions, etc., it rarely happens that a transmitted scene is as simple as that shown in Fig. 6(*a*). Instead, most scenes to be transmitted have a considerable amount of detail and variations in light and shade, and the waveform shown in Fig. 7 (*a*) could correspond to the signal transmitted during a single line of a scene encountered in practice. Although Fig. 7 (*a*) shows considerable changes in amplitude during the transmitted line, an actual transmission could contain even more detail (i.e. short-time changes in amplitude) than it is possible to reproduce in a small printed diagram. It is usual practice, when referring to television signal waveforms in technical publications, to employ diagrams similar to that of Fig. 7 (*b*).

Line Synchronising

When the television signal is received, the strength of the electron beam in the cathode ray tube varies according to the output of the transmitter. At the same time, the electron beam in the receiver is deflected so that it traces out the same pattern as that in the transmitting camera. So long as the beams in the receiver and in the transmitter are deflected exactly in synchronism with each other, we are then able to build up the transmitted picture at the receiving end.

This brings us to our second important point: how do we keep the two deflection systems, one at the transmitter and the other at the receiver, exactly in step with each other? A simple method of doing this consists of transmitting special synchronising signals which can be separated from the picture signal by the receiver, and which can be used to control its deflection circuits. The process is, fortunately, fairly simple, and it enables the receiver to be synchronised with the transmitter without excessive cost in the former. It will be easiest to commence by considering the process used for *line* deflection circuits only at this stage.

We already know that, after we have scanned a line at the receiver, it is necessary for the spot to fly back to the left-hand side again in order to scan the next line. The line flyback is not instantaneous; it requires, instead, a short time to take place, and it would be inadvisable to transmit any picture signal (or picture "information") until the next line starts. At the same time, the simplest

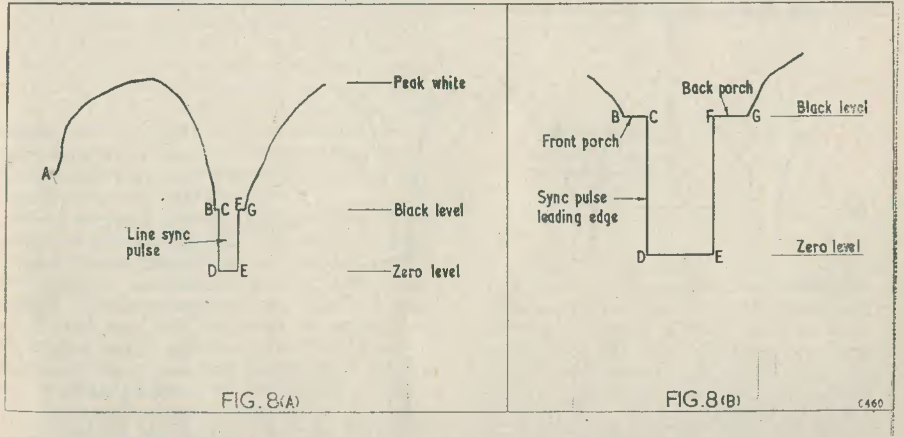


FIG. 8(A) FIG.8(B)

Fig. 8 (a) Simplified diagram showing how a line sync pulse may be transmitted between picture information in successive lines. (b) The various parts of the waveform around the line sync pulse. (The waveform shown here is equivalent to the pre-1956 BBC standard) method of synchronising the receiver line deflection circuits consists of transmitting a synchronising signal which *initiates* the flyback after the scanning of a line has been completed. (This point will be explained in greater detail in a later article.) Due to these requirements it becomes not only feasible but actually desirable, to transmit line synchronising signals during the flyback period.

Fig. 8 (*a*) illustrates two successive lines of a television picture, and shows how *synchronising pulses* can be transmitted at the end of each line. A positive modulation system is in use. Starting at the point A in Fig. 8 (*a*) we encounter our normal, detailed picture signal, this continuing until we reach the end of the line at point B. At point B the signal stays for a short time at black level until, at point C, it suddenly drops to zero level at D. After a further short period the level suddenly rises, from E, to black level at F, and carries on to G. After G the picture information for the next line appears once more. That part of the waveform occurring between points C and F is the synchronising pulse (or *sync pulse*).

The waveform between successive lines is shown in greater detail in Fig. 8 (*b*), the points B to G in this diagram corresponding to the same points in Fig. 8 (*a*). In Fig. 8 (*b*) the various parts of the waveform and the sync pulse are named. The period at black level from point B to point C is described as the *front porch* of the synchronising pulse. The line CD is the *leading edge* of the sync pulse, whilst line FG is the *back porch* of the sync pulse. It will be noted that, over the period B to G, the signal transmitted is either at black level or below black level with the result that in a correctly adjusted receiver no part of it can affect the cathode ray tube beam, this being cut off during the entire period. In earlier literature the somewhat expressive term "blacker-than-black" (describing that part of the signal below black level) may sometimes be met to describe signal levels below lines BC and FG. Fig. 8 (*a*), incidentally, represents approximately the proportions of the British transmitted waveform. The bottom of the sync pulse (line DE) corresponds to zero output. Black level (lines BC and FG) correspond to 30% of full transmitter output, full transmitter output being represented by the highest point in the picture waveform. The highest point is referred to as *white level* or *peak white level.* (It is assumed that part of the picture information in Fig. 8 (*a*) consists of peak white.)*

Fig. 8 (*a*) and (*b*) shows how the line synchronising pulse is added to the picture information to provide the composite television signal. In order to take advantage of the sync pulse, it is obviously necessary for the receiver to be able to separate it from the remainder of the signal so that it may be fed to the appropriate line deflector circuits. In practice this is done by applying the whole waveform to a "clipper" or *sync separator,* which is capable of handling only that part of the signal which is occupied by the sync pulses. A typical sync separator circuit may function by being so connected that it can only handle signals having an amplitude lower than, say, line XY in Fig. 9 (*a*). The output of the sync separator could then take the form shown in Fig. 9 (*b*), wherein only the sync pulses are present.

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* This simplified description applies to B.B.C. standards before 1956. The waveform currently employed will be described in full detail in next month's issue.

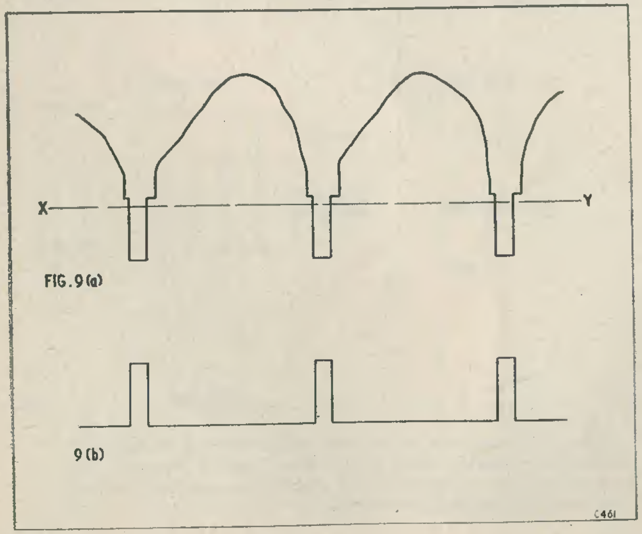


Fig. 9. A simple method of separating line sync pulses from the transmitted signal consists of employing an amplifier which cannot handle signals having an amplitude higher than, say, line XY in (*a*). *The output of such an amplifier would then be of the nature shown in* (*b*). *It is assumed that the amplifier inverts the waveform*

Before carrying on, it is worth devoting a little more time to Fig. 8 (*a*). We have already referred to the front porch, but we have not yet discussed the reason for its existence. The necessity for having a front porch is that it is impossible to design practical receiver circuits capable of responding instantaneously to changes in signal strength. There is always some slight delay, even if this is normally of a very small order. However, a very short delay could cause synchronising difficulties if the right-hand edge of the picture happened to be at peak white level, as it is in Fig. 10 (*a*). If there were no front porch we would then be asking the receiver circuits to follow instantaneously a sudden change, not only from white to black, but from white to "blacker-than-black." The inevitable delay resulting from such a long excursion could give the effect shown in Fig. 10 (*b*), wherein the leading edge of the sync pulse is delayed. (The transmitted waveform, assuming no front porch, is shown in dotted line in Fig. 10 (*b*)). Fig. 10 (*c*) shows the same peak white signal appearing at the right-hand edge of the line, but there is, on this occasion, a front porch. The receiver circuits could then reproduce this as Fig. 10 (*d*) (correct waveform shown dotted). Even though a delay still exists in the receiver circuits, the presence of the front porch provides sufficient time for the waveform to drop to black level before the sync pulse starts. The sync pulse, therefore, is unaltered and its leading edge appears at the correct instant.

The back porch, similarly, provides time for the receiver circuits to rise to black level after the sync pulse has ended and preparatory to the commencement of the next line, but this is not its only function. Its other purpose is that of keeping the receiver at black level until the spot on the cathode ray tube has completed its flyback and has commenced to scan the next line. In British transmissions the back porch is approximately four times longer than the front porch.

We said just now that the simplest method of synchronising receiver line deflector circuits consists of having their flyback action initiated by the leading edge of the transmitted synchronising pulse itself. Such receivers could be described as employing direct line synchronisation. In these types of receiver it then becomes necessary to ensure that the time taken up by the flyback period is always less than that taken up by the sync pulse and the back porch together (i.e. from C to G in Fig. 8 (*b*)).

Direct line synchronising circuits are normally employed in cheaper receivers

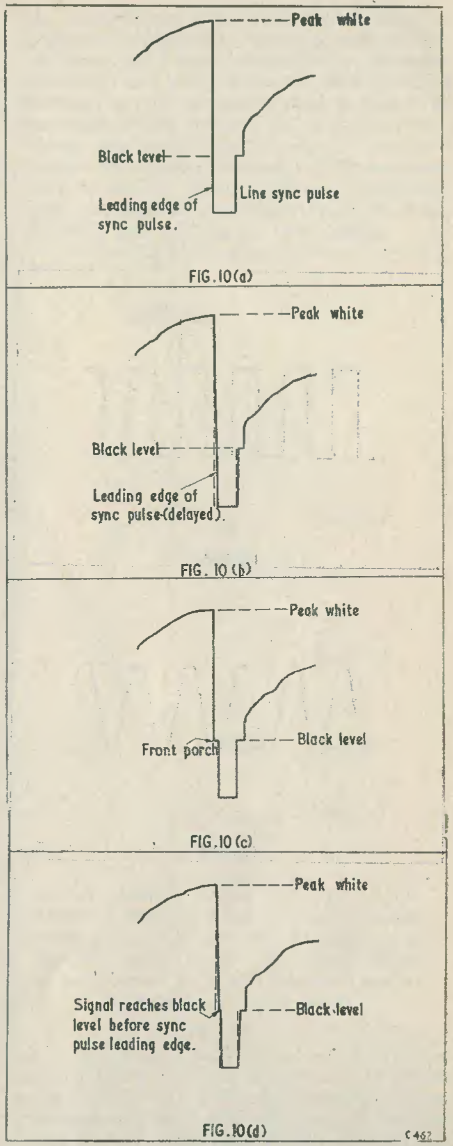


Fig. 10 (*a*). *The waveform which would be given at the end of a line terminating in a peak white signal if there were no front porch.* (*b*) *The inevitable delay occurring in the receiver circuits would cause the leading edge of the sync pulse of* (*a*) *to be delayed.* (*c*) *The waveform of* (*a*) *with a front porch added.* (*d*) *The presence of the front porch allows time for the waveform to reach black level before the commencement of the sync pulse* intended for use in strong signal areas. In such areas a good non-fading signal is normally obtainable; and the receiver, together with its aerial, does not require to have such a high sensitivity that it becomes over-susceptible to ignition interference and the like. (Ignition interference, and similar interference of a pulse-like character, may, if sufficiently strong relative to the desired signal, break through the sync separator stage of a receiver and cause the line deflector circuits to commence flyback before the arrival of the transmitted sync pulse.) To overcome the problems of fading and interference, receivers intended for fringe areas usually employ *flywheel sync* arrangements for the line deflector circuits. Line flywheel sync circuits are more complicated than direct sync circuits and employ an oscillator whose frequency is continuously *compared* with the frequency at which the transmitted sync pulses appear. If the oscillator attempts to run at too high a frequency, a control voltage is applied to it which reduces its frequency. Similarly, if the oscillator attempts to run at too low a frequency, a control voltage of opposite polarity brings it up again. The great advantage of the flywheel sync arrangement is that it responds relatively slowly to changes in sync pulse, or oscillator, frequency with the result that it can continue at correct frequency even when a number of sync pulses are lost through excessive fading or when very strong pulse interference is present. Since it operates by comparing two frequencies, the flyback in a line flywheel circuit is not initiated by the leading edge of the sync pulse, and it may commence at any time relative to that leading edge. It is often a little difficult to make the flyback in a line flywheel sync circuit always commence at exactly the same point in the waveform at the sync pulse, there frequently being a slight amount of drift with time due to thermal changes as the associated receiver warms up, plus long-term drift due to pre-set controls falling out of alignment. The period of time taken up by the flyback, when flywheel sync is used, has therefore to be sufficiently short for it to be completed before the start of the next line, even when drift causes its commencement to be later than the leading edge of the sync pulse. There is, in consequence, usually "less-in-hand" so far as flyback time is concerned when flywheel sync is employed than there is with directly synchronised line circuits.

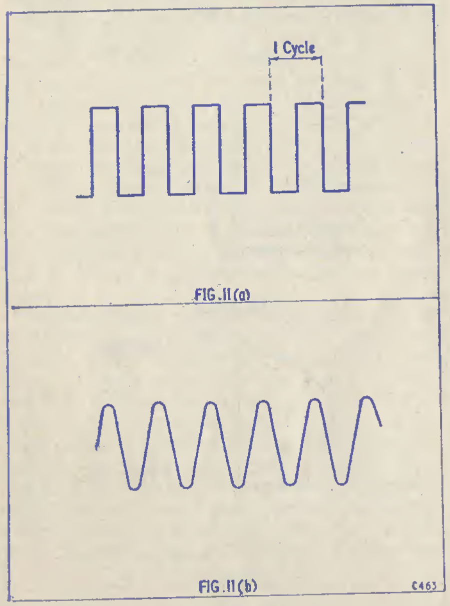


Fig. 11 (a) For perfect reproduction at limiting picture signal frequency, it should be possible to transmit the square wave shown here. (b) In practice, the top picture frequency has to be transmitted as a sine wave, as illustrated

Frame Synchronising

Whilst line synchronising is a relatively simple function to understand, the processes employed for frame synchronising necessitate rather more understanding of circuit functions than is assumed at this stage. It should be mentioned, however, that frame sync signals are transmitted to keep the frame deflector circuits in step with those at the transmitter, but that these do not take the simple form exhibited by the line sync pulse.

In the BBC signal, the frame sync signals occupy the same amount of time as 14 complete lines. Although the frame sync pulse is of a considerably different nature to the line sync pulse, it is made up such that what are effectively line sync pulse leading edges are still transmitted throughout its duration. In consequence the line deflector circuits remain synchronised throughout the frame flyback, thereby ensuring that they are running correctly at the commencement of the next frame. The waveform employed for the frame synchronising pulse will be illustrated in next month's issue, but we shall not enter into any detailed description of how it is used until we come to consider sync separator circuits.

Picture Definition

We have devoted some time to describing the sync pulses which form an essential part of the transmitted television signal, and we should conclude this preliminary simplified discussion by considering the picture information itself.

There are several factors which now have to be dealt with. The first of these is concerned with the amount of picture definition or detail which the television system is capable of handling. If a picture to be transmitted contains a considerable amount of detail it is obvious that the frequency at which the picture signal amplitude changes will be greater than when there is little detail. In a practical television transmission system it is desirable to set a top limit to the picture signal frequency which may be handled, this being due basically to the necessity of keeping the sidebands on the transmitted carrier, which is modulated by the picture signal, to the minimum amount commensurable with a satisfactory picture.

When the BBC standards were originally decided upon, it was felt that there was little point in transmitting greater detail in the horizontal sense than could be obtained in the vertical sense. In the vertical sense picture detail is limited to the scanning line structure, whereupon it becomes impossible to transmit any vertical detail that is smaller than the width of one line of the picture. Horizontal detail of the same standard would be provided at a picture information frequency of 3 Mc/s, and it was decided to make this the highest signal frequency to be handled. With such a top frequency it is theoretically just possible to transmit a chequerboard pattern, the sides of the squares of which are equal to the width of one scanning line. In the vertical sense, alternate black and white squares would appear on alternate scanning lines and could thereby be observed on the screen of the receiver. In the horizontal sense the alternate black and white squares would just be distinguishable, as they would represent limiting picture information frequency.

In practice we would not be able to transmit the black and white squares perfectly in the horizontal sense because, to do this, we would require our picture information waveform to take up the square wave appearance shown in Fig. 11 (*a*). However, our top frequency is, in actual fact, a *sine wave* like that of Fig. 11 (*b*) and so, in the reproduced picture, the edges of the chequerboard squares would not be as sharp in their change from black to white, or from white to black, as they should ideally be. Unfortunately, to transmit a 3 Mc/s square wave perfectly would require a bandwidth of many times this frequency; and we therefore accept the limitations set by the top frequency *sine* wave.

Transient Response

A second important factor which has to be considered when dealing with the television signal is given by sudden changes from black to white, or from white to black. We have already observed that a slight delay in following such changes is inevitable in receiver circuits when we discussed the necessity for the front porch before the line sync pulse. However, this is not the only way in which sudden changes in picture amplitude may be distorted.

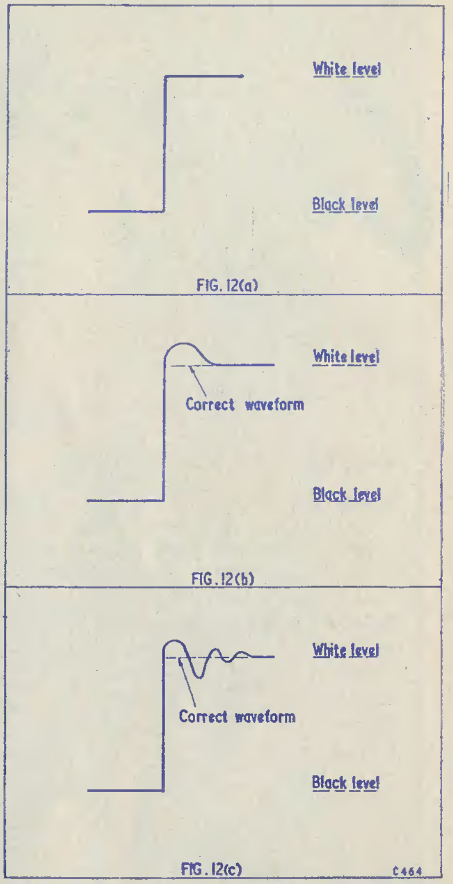


Fig. 12 (a) A sudden change in waveform amplitude over part of a transmitted line. (b) Illustrating overshoot. (c) An example of ringing

The ability of a transmitting and receiving system to reproduce sudden changes is described as its *transient response*. Fig. 12 (*a*) illustrates part of a horizontal line wherein a black section changes suddenly to white. A waveform of the type shown in Fig. 12 (*b*) illustrates *overshoot* (a self-explanatory term); whilst that of Fig. 12 (*c*) exhibits *ringing*.

(*continued on page 485*)

The Cooper-Smith Mk. II CONTROL UNIT

by J. COOPER

Technical Details

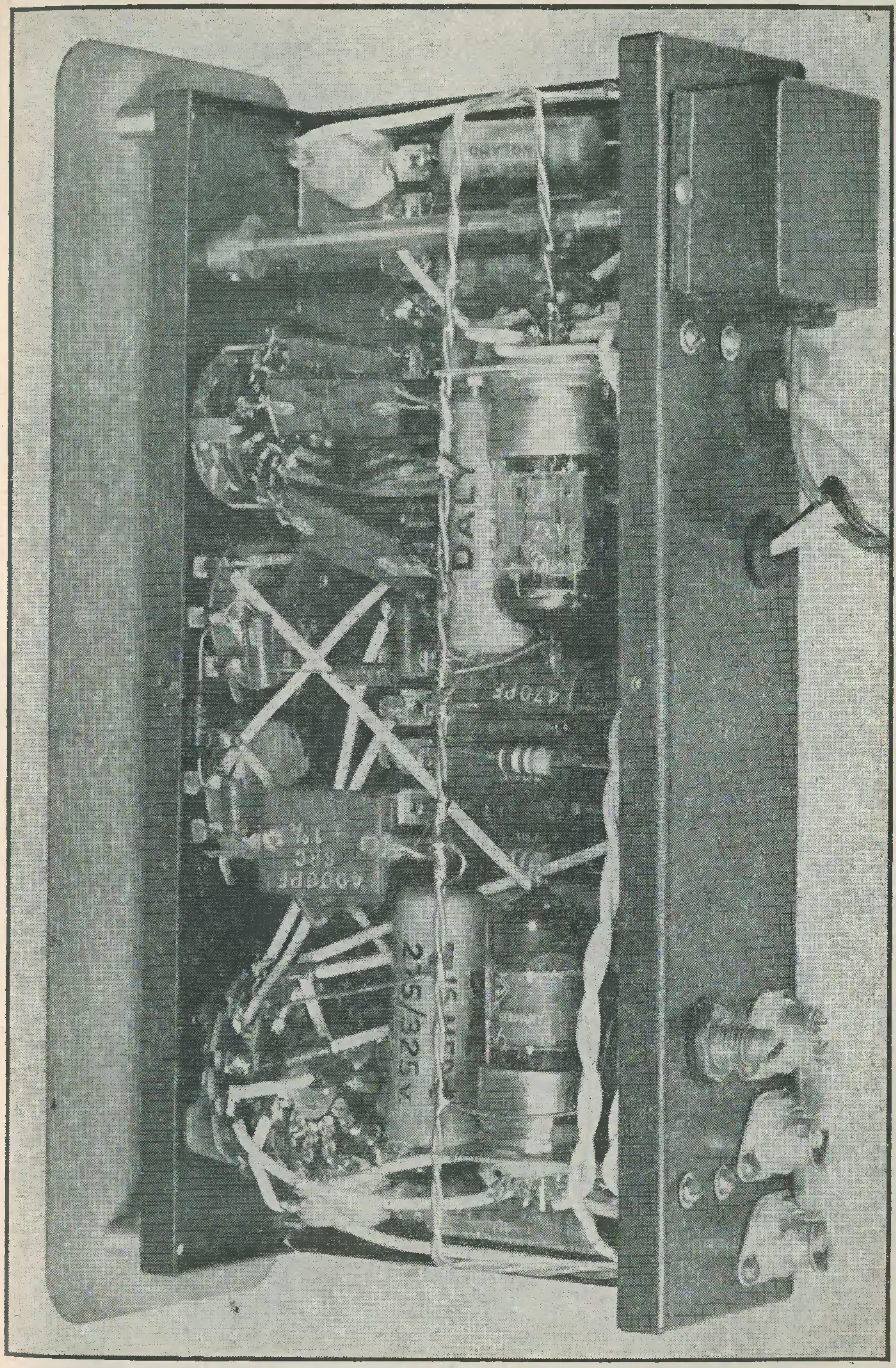
Valve Line-up	6267 (EF86) 12AX7 (ECC83)
Inputs: Radio, Gramophone, Microphone, Equalised Tape	
Filter—Approx. 12dB per octave cut at 10 kc/s, 8 kc/s and 6 kc/s	
Bass and Treble lift and cut	
Width	9¼in
Height	2¼in
Depth	5¾in overall
Panel	10in × 3½in

Input Sensitivities:	
Radio and Tape	100mV
Gramophone	3mV
Microphone	1.5mV
Output	1.75V
Input Impedance	100,000Ω
Switch Positions:	
1	Radio
2	L.P.
3	78
4	Early L.P.
5	Mic.
6	Tape

General Description (*see Fig.* 4)
Stage 1

THIS EMPLOYS A LOW NOISE, HIGH GAIN pentode (6267) with negative feedback from anode to grid. On the three pick-up switch positions the feedback becomes frequency selective, providing the appropriate equalisation for the playback of disc recordings. As most modern L.P. recordings are made with a standardised R.I.A.A. characteristic, it was decided that only one main L.P. equalisation network was necessary, and any departure from the correct curve could be compensated for by judicious use of the wide-range tone controls. However, provision has been made for the playing of older L.P. recordings which were recorded at a somewhat lower level and require bass correction at a slightly higher frequency. The 78 r.p.m. equalisation is based on the E.M.I. curve, and with the use of tone controls and filter this should cater for all types of recording characteristics.

The pick-up input will accommodate practically any type of pick-up, including crystals which have been loaded to give an output proportional to stylus velocity, which means that the crystal pick-up behaves very much like a magnetic. The Collaro transcription pick-up will feed straight in, as the input volume control is of the correct value (100kΩ) and is all that is necessary for the constant velocity conversion.



Underneath view from rear of the Cooper-Smith Mk. II Control Unit

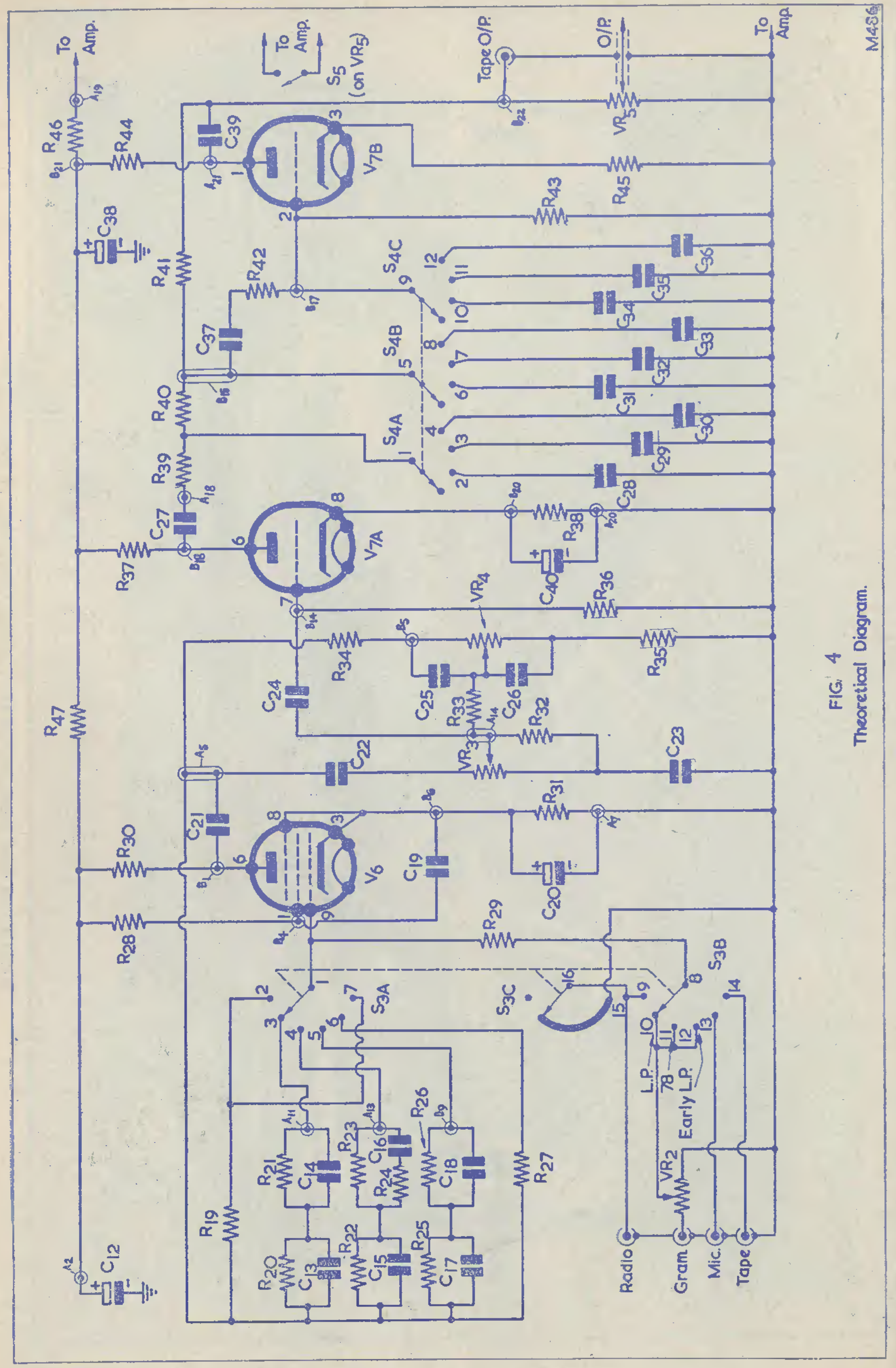


FIG. 4
Theoretical Diagram.

COMPONENTS LIST

R_{19}	47kΩ ½W 10% High Stability, T.S.L.
R_{20}	12MΩ ¼W 20%
R_{21}	1.2MΩ ½W 10% High Stability, T.S.L.
R_{22}	10MΩ ½W 10% High Stability, T.S.L.
R_{23}	1.2MΩ ½W 10% High Stability, T.S.L.
R_{24}	680kΩ ½W 10% High Stability, T.S.L.
R_{25}	12MΩ ¼W 20%
R_{26}	3.3MΩ ½W 10% High Stability, T.S.L.
R_{27}	18MΩ ¼W 20%
R_{28}	1.5MΩ ½W 10% High Stability, T.S.L.
R_{29}	68kΩ ½W 10% High Stability, T.S.L.
R_{30}	270kΩ ½W 10% High Stability, T.S.L.
R_{31}	3.9kΩ ½W 10% High Stability, T.S.L.
R_{32}	47kΩ ½W 10% High Stability, T.S.L.
R_{33}	39kΩ ½W 10% High Stability, T.S.L.
R_{34}	68kΩ ½W 10% High Stability, T.S.L.
R_{35}	6.8kΩ ½W 10% High Stability, T.S.L.
R_{36}	2.2MΩ ½W 10% High Stability, T.S.L.
R_{37}	100kΩ ½W 10% High Stability, T.S.L.
R_{38}	2.2kΩ ½W 10% High Stability, T.S.L.
R_{39}	82kΩ ½W 10% High Stability, T.S.L.
R_{40}	68kΩ ½W 10% High Stability, T.S.L.
R_{41}	820kΩ ½W 10% High Stability, T.S.L.
R_{42}	47kΩ ½W 10% High Stability, T.S.L.
R_{43}	2.2MΩ ½W 10% High Stability, T.S.L.
R_{44}	100kΩ ½W 10% High Stability, T.S.L.
R_{45}	2.2kΩ ½W 10% High Stability, T.S.L.
R_{46}	15kΩ ½W 10% High Stability, T.S.L.
R_{47}	100kΩ ½W 10% High Stability, T.S.L.
VR_2	100kΩ Lin.
VR_3	250kΩ Log
VR_4	250kΩ Log
VR_5	100kΩ Lin. with switch
V_6	6267 (EF86) Tungsram
V_7	12AX7 Tungsram

Chassis, with fittings and grommets and control panel*
Group Board, 22-way, 2¾in wide, with insulating sheet*
Switch (S3) 6-way, 2-pole, 2-bank, special*
Switch (S4) 4-way, 3-pole, small

C_{12}	16μF 275V wkg., Daly
C_{13}	270pF mica 1% tol.
C_{14}	68pF mica 1% tol.
C_{15}	470pF mica 1% tol.
C_{16}	68pF mica 1% tol.
C_{17}	270pF mica 1% tol.
C_{18}	68pF mica 1% tol.
C_{19}	0.1μF 350V wkg. paper tubular, Static
C_{20}	50μF 12V wkg. electrolytic
C_{21}	0.1μF 350V wkg. paper tubular, Static
C_{22}	560pF mica 1% tol.
C_{23}	8,000pF (2×4,000) mica 1% tol.
C_{24}	0.05μF 350V wkg., Static
C_{25}	2,200pF mica 1% tol.
C_{26}	0.02μF Moldseal
C_{27}	0.05μF 350V wkg. paper tubular, Static
C_{28}	270pF mica 1% tol.
C_{29}	330pF mica 1% tol.
C_{30}	400pF mica 1% tol.
C_{31}	470pF mica 1% tol.
C_{32}	1,500pF mica 1% tol.
C_{33}	1,800pF mica 1% tol.
C_{34}	390pF mica 1% tol.
C_{35}	470pF mica 1% tol.
C_{36}	560pF mica 1% tol.
C_{37}	820pF mica 1% tol.
C_{38}	16μF 275V wkg., Daly
C_{39}	0.05μF 350V wkg. paper tubular, Static
C_{40}	50μF 12V wkg. electrolytic, Daly

Valveholders, B9A, PTFE, with skirt (2)
Co-axial sockets (5)
Co-axial plug
Octal plug
Spindle extension
Knobs, indicator, cream, set of 5
Nuts and screws, Co-axial lead, T.C. wire, busbar, flex sleeving (4 colours), solder tag

* H. L. Smith & Co. Ltd.

The output of the stage is fed into a "losser" type of tone control circuit, and with the chosen component values, the frequency response is substantially flat at 50% of rotation of the Bass and Treble potentiometers. Approximately 15dB of bass and treble lift and cut are provided at settings either side of the central positions.

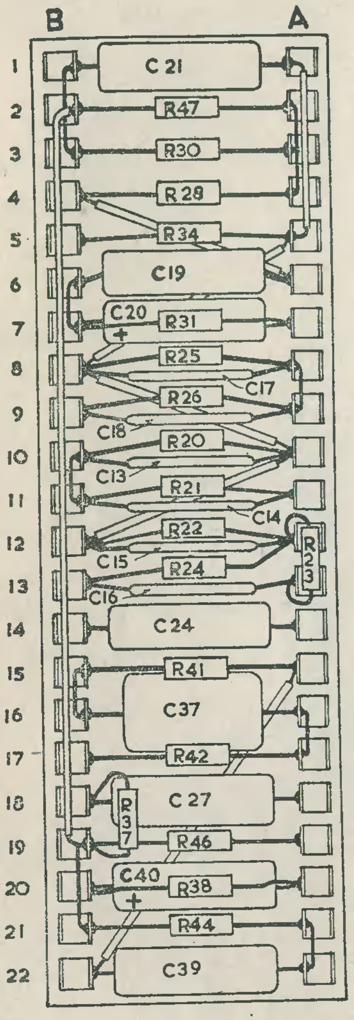
The input sensitivities on the remaining switch positions are controlled by fixed amounts of feedback.

Stage 2

This is essentially a voltage amplifier and performs no function other than to make up for the loss of gain due to the tone control circuit. The output of this stage is fed into the low-pass filter. By the use of resistance-capacity networks and negative feedback, the latter provides an attenuation of better than 12dB per octave of frequencies above 10 kc/s, 8 kc/s and 6 kc/s respectively, these being selected by S_4. The filter is not usually necessary on L.P. records, but it can prove invaluable in suppressing unwanted noise such as heterodyne whistles on a.m. signals or surface noise on shellac records. A rumble filter is also incorporated in the circuit to attenuate frequencies below 35 c/s, thereby preventing sub-audio frequencies from overloading the system. These latter frequencies are produced in the main by mechanical noises in cheap or faulty gramophone motors, especially when the listener favours accentuated bass in his reproduction.

Stage 3

We now come to the output stage. This provides negative feedback for the filter and



GROUP BOARD

Layout and wiring diagram.

FIG.5

Note: In the above diagram tags B1 and B3 are connected together with insulated wire. There is no connection between them and tag B2.

a relatively low impedance source for feeding the main amplifier. The volume control is connected to the output end of the stage so that internal noises such as hum, valve hiss, etc., are reduced in direct relation to the signal. The output impedance is sufficiently low to enable the control unit to be used at some distance from the main amplifier if desired without undue attenuation of the higher frequencies. In this case it is advisable that the power supplies for the unit be provided from a separate source, and that the connecting cable be of the low capacitance type such as the co-axial used in television and v.h.f. aerial feeders.

Input Sensitivities

Radio and equalised tape	100mV
Gram (with input pot. fully open)	3mV
Microphone	1.5mV

At the above sensitivities the unit will deliver approximately 1.75 volts with an extremely low level of hum, noise and distortion. This is more than sufficient to fully load the main amplifier.

Tape

To enable the amplifier to be used for the high-quality reproduction of pre-recorded tapes, a co-axial socket is provided and is shown as "Tape Input." This may be fed from the output jack of a tape pre-amplifier such as the Reflectograph "Brick" unit or a complete tape recorder with a high impedance output.

A "Tape Output" socket connected in parallel with the output of the unit enables it to be used for feeding a high impedance tape recorder with signals from the Microphone, Gramophone or Radio inputs. The volume control in this case is inoperative, volume level being controlled at the recording amplifier.

Construction

For ease of wiring, as many as possible of the resistors and condensers are fitted to a group board, which can be made up before fitting to the chassis. Wire up as shown in Fig. 5, commencing with the connecting wires, and check carefully to make sure that connections are correct and complete.

Fit components to chassis in the following order:

- Co-axial sockets (solder tag on Mic. input)
- VR_5 bracket
- Group board (use spacers to keep clear of chassis)
- Switches and Potentiometers (leave ext. spindle of VR_5 until after wiring)
- Valveholders.

It is important that the components are positioned as shown on the layout diagram

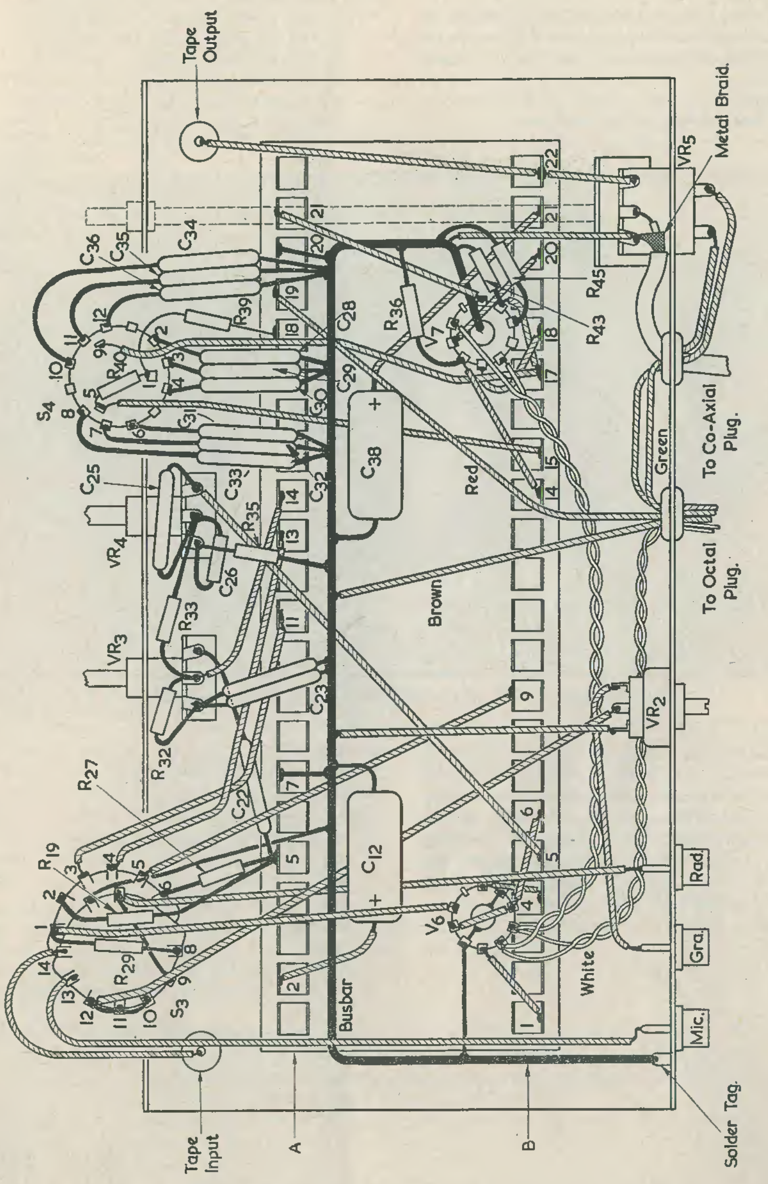


FIG.6.
Layout and Wiring Diagram.

Tags 4 and 5 on V_7 should be connected together. The output lead (co-ax.) is wired to VR_5 as shown

(Fig. 6). The switches and valveholders are shown turned up so that the connections may be clearly seen, but they are shown in the correct position that they would assume if turned back.

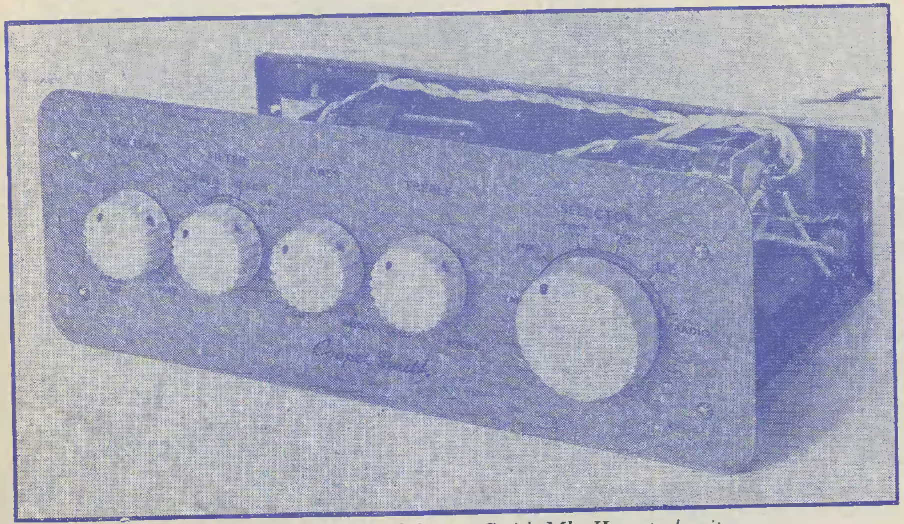
Ensure that the co-axial sockets and valveholder brackets make good earth contact by first scraping enamel from chassis at fixing holes.

Resistors must not touch each other or anything but an insulating surface.

B18–V_7 tag 6
B20–V_7 tag 8
B22–VR_5 tag 3–Tape O/P

Then proceed as follows, keeping leads as short as possible.

S_3 tag 16–S_3 tag 9
S_3 tag 10–tag 11–tag 12
S_3 tag 14–Tape input
S_3 tag 8–R_{29}–S_3 tag 1
VR_3 tag 1–R_{32}–VR_3 tag 2
VR_3 tag 2–R_{33}–VR_4 tag 2



Control panel view of Cooper-Smith Mk. II control unit

Now make connections to group board as follows. Only those tags which are to be connected up are numbered on the wiring diagram, and these points are also shown circled on the theoretical diagram for checking purposes. Tags on the potentiometers are numbered 1 to 3 reading from left to right and on valveholders 1 to 9 reading clockwise.

A5–R_{27}–S_3 tag 6
A5–R_{19}–S_3 tag 2
A5–C_{22}–VR_3 tag 3
A11–S_3 tag 3
A13–S_3 tag 4
A14–VR_3 tag 2
A18–R_{39}–S_4 tag 1
A21–V_7 tag 1
B1–V_6 tag 6
B4–V_6 tag 1
B5–VR_4 tag 3
B6–V_6 tag 3
B9–S_3 tag 5
B14–V_7 tag 7
B15–S_4 tag 5
B17–S_4 tag 9
B17–V_7 tag 2
VR_4 tag 2–C_{25}–VR_4 tag 3
VR_4 tag 1–C_{26}–VR_4 tag 2
S_4 tag 1–R_{40}–S_4 tag 5
V_6 tag 2–Spigot–tag 7
V_6 tag 3–tag 8 (insulate wire)
V_6 tag 9–S_3 tag 1
S_3 tag 13–Mic. input
VR_2 tag 3–Gram. input
S_3 tag 16–Radio input
VR_2 tag 2–S_3 tag 12
Solder tag on Mic. input–spigot on V_7 using busbar (do not earth at any other point)
V_6 spigot–busbar
VR_2 tag 1–busbar
VR_5 tag 1–busbar
Grp. bd. A7–busbar
Grp. bd. A20–busbar
VR_4 tag 1–R_{35}–busbar
VR_3 tag 1–C_{23}–busbar
S_3 tag 15–busbar
S_4 tag 2–C_{28}–busbar
S_4 tag 3–C_{29}–busbar
S_4 tag 4–C_{30}–busbar
S_4 tag 10–C_{34}–busbar

S_4 tag 11–C_{35}–busbar
S_4 tag 12–C_{36}–busbar
S_4 tag 6–C_{31}–busbar
S_4 tag 7–C_{32}–busbar
S_4 tag 8–C_{33}–busbar
V_7 tag 2–R_{43}–busbar
V_7 tag 3–R_{45}–busbar
V_7 tag 7–R_{36}–busbar
Grp. bd. A2–C_{12}–busbar (neg.)
Grp. bd. B21–C_{38}–busbar (neg.)

The connection between tags 2 and 7 on S_3 is already made.

Now connect up heaters as follows. (These are not shown on theoretical diagram to avoid complication of circuit).

Join tags 4 and 5 on V_7 and connect piece of white flex. Connect piece of white flex to tag 9, twist two together and take to tags 4 and 5 on V_6.

Power leads are now made up as follows: using white flex, connect to tags 4 and 5 on V_6, twist together and pass through grommet in chassis. Join brown flex to busbar, red flex to A19 on group board and green pair to switch on VR_5. Pass these through grommet, plait up, cut off to length required and connect to octal plug thus:

White pair to pins 2 and 7
Green pair to pins 4 and 5
Red to pin 6
Brown to pin 3.

IN YOUR WORKSHOP

(*continued from page 470*)

"The final thing I want to say concerns an experience I had some time ago with an unstable sound i.f. strip, which I simply could not cure by replacement components. The repair I finally made may be of interest to others similarly placed. The strip only went unstable when the coils were lined up fairly accurately, but this did not mean, of course, that the trouble could be ignored. So far as I could ascertain, the cause of oscillation was an EF80 which had high-Q coils in both anode and grid circuits, the layout around the valveholder being something like this (Fig. 5 (*a*)). I cured the trouble finally, and very reliably, by adding a further earthing lead (Fig. 5 (*b*)). I should imagine that this not only gave a lower impedance to chassis but also provided the small additional amount of electrostatic screening which was needed between anode and grid. I don't like adding bits to receiver layouts, but in this case it was the only thing I could do."

"Needs must when the devil drives" commented Dick.

"I couldn't agree more," replied Smithy, "and instability can sometimes be a devil indeed."

UNDERSTANDING TELEVISION

(*continued from page 477*)

Ringing is caused by one or more tuned circuits in the receiver being *shock-excited* by the sudden change in signal strength, these circuits producing a damped train of oscillations (i.e. a succession of *sine* waves which die away) at the frequency to which they are tuned.

Next Month

In this article we have discussed, in extremely general terms, the nature of the transmitted signal together with its limitations and its usefulness in the television system. To obtain a final and more complete idea of the signal it is necessary to consider it in absolute terms of frequency and time. This we shall do in next month's article, wherein we shall also compare the British 405 line standard with the American 525 line and the C.C.I.R. 625 line system used on the Continent and in Australia.

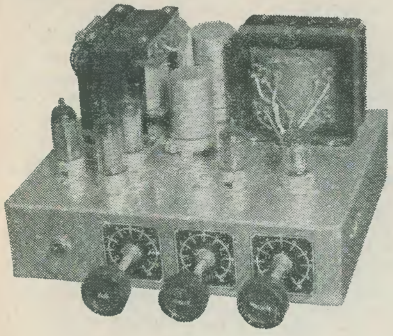
ERRATA

Switch Tuned Superhet

In the circuit given on page 418, January issue, the rectifier 6x5 was incorrectly shown as being connected to the 5 volt heater winding point. An indirectly heated 5 volt rectifier may be substituted if desired, or the 6x5 connected to the 6.3B winding.

NEXT MONTH . . .

The HI-GAIN Band III Pre-Amplifier
A cascode circuit using the Mullard ECC84



The "VIRTUOSO"

A design for an 11-watt Hi-Fi Amplifier

by **W. E. THOMPSON** A.M.I.P.R.E.

Amplifiers for quality reproduction seem to have reached a point where the design follows a generally accepted pattern of pentode voltage-amplifying stage, phase inverter and push-pull output stage, the power output being in the region of 10 to 15 watts of audio with low distortion. Negative feedback in some form or other is usually incorporated to linearize the frequency response, reduce distortion, and improve the damping factor.

The design presented here does not depart essentially from these basic requirements, although it has certain features that result in ample output for normal uses, good reproduction, and simple circuitry. It is not unduly large or heavy, nor is it expensive or difficult to build. Tone controls for treble and bass are included, and the output stage is operated in Class AB1 under distributed load (or "ultra-linear") conditions. A less usual feature for an amplifier of this type is the use of a small amount of positive feedback which improves the damping factor of the speaker.

The circuit is shown in Fig. 1. The input stage is the usual voltage-amplifying pentode, using a Brimar 6BR7, which was chosen for its low hum factor and high stage gain. Input is controlled by the 500kΩ potentiometer R_1, and it will be seen that the circuitry around this valve follows normal practice. Correction networks for various forms of input are not included since these will depend upon the equipment used to drive the amplifier.

The tone control network for bass and treble is connected between the anode of V_1 and the grid of the first section of the phase inverter stage V_2. R_7 is the bass control and R_8 the treble control. Values of components in the network are such that about 15.5dB boost is obtained with the controls at their maximum positions, on the assumption that the 3dB points for bass and treble are 200 c/s and 2 kc/s respectively. If desired, values of the components can be altered in accordance with the formulas given below to give other degrees of boost and for different frequencies for the 3dB points. The value of R_5 is approximately the input impedance of the network over most of the range. Normally it should not be less than 100kΩ. In practice, it will be found that values of 100kΩ or 200kΩ for R_5 are the most practicable, since the values of R_7 and R_8 are entirely dependent upon it. At the same time, one is restricted to standard values of potentiometers, and values higher than 2MΩ are seldom obtainable as stock items.

By applying the formulas in the order given, the values for the other components can be worked out in logical sequence. It should be noted, however, that the quotient obtained by dividing the desired boost (dB) by 20 is to be treated in the calculation as if it is a logarithm and the actual antilog found from log tables in the usual way. If, for example, dB/20 is 0.9675 this is regarded as a logarithm whose characteristic is zero and the mantissa .9675.

In the formulas below, f_1 is the low frequency (bass) 3dB point, f_2 the high frequency (treble) 3dB point, both of which values should be inserted in terms of c/s. Values of R are in ohms, and C is in μF and pF where stated. Wherever possible, the working should be shortened by using indices to powers of 10.

$$R_5 = \text{not less than } 100\text{k}\Omega$$

$$R_7 = R_8 = 10R_5$$

$$R_6 = \frac{R_5}{\left(\text{Antilog}\,\frac{\text{dB}}{20}\right) - 1}$$

$$C_{10} = \frac{1.6\times10^5}{f_1\times R_5}\,\mu\text{F}$$

$$C_6 = \frac{f_1}{f_2}\times10^5 C_{10}\ \text{pF}$$

$$C_9 = \frac{R_8\times C_6}{10R_6}\ \text{pF}$$

An example will assist in showing the use of the formulas. Assume the requirements to be 22dB boost with the bass and treble 3dB points at 320 c/s and 3.2 kc/s respectively. R_5 is to be 100kΩ. Applying each formula in turn:

$$\begin{aligned} R_7 = R_8 &= 10R_5 \\ &= 10\times10^5 \\ &= 10^6 \\ &= 1.0\text{M}\Omega \end{aligned}$$

$$\begin{aligned} R_6 &= \frac{R_5}{\left(\text{Antilog}\,\frac{\text{dB}}{20}\right) - 1} \\ &= \frac{10^5}{\left(\text{Antilog}\,\frac{22}{20}\right) - 1} \\ &= \frac{10^5}{\left(\text{Antilog } 1.1000\right) - 1} \\ &= \frac{10^5}{12.59 - 1} \\ &= \frac{10^4}{1.159} \\ &= 8.63\times10^3 \\ &= 8.63\text{k}\Omega \end{aligned}$$

This is not a standard value, the nearest values in 5% tolerance being 8.2kΩ and 9.1kΩ. The required value could be obtained with 10kΩ in parallel with 62kΩ, which gives 8.61kΩ.

$$\begin{aligned} C_{10} &= \frac{1.6\times10^5}{f_1\times R_5} \\ &= \frac{1.6\times10^5}{3.2\times10^2\times10^5} \\ &= \frac{5\times10^{-1}}{10^2} \\ &= 5\times10^{-3} \\ &= 0.005\mu\text{F} \end{aligned}$$

$$\begin{aligned} C_6 &= \frac{f_1}{f_2}\times10^5 C_{10} \\ &= \frac{3.2\times10^2\times10^5\times5\times10^{-3}}{3.2\times10^3} \\ &= 5\times10 \\ &= 50\text{pF} \end{aligned}$$

$$\begin{aligned} C_9 &= \frac{R_8\times C_6}{10R_6} \\ &= \frac{10^6\times5\times10}{8.63\times10^4} \\ &= \frac{5\times10^3}{8.63} \\ &= 5.8\times10^2 \\ &\doteq 580\text{pF} \end{aligned}$$

The output from the tone control network is taken to the Brimar 12AX7, connected as a floating paraphase self-balancing phase inverter. This particular circuitry was chosen for its simplicity and stability, bearing in mind the ease of applying positive feedback to it. The necessary feedback is obtained through the 200Ω resistor R_{14} which is common to both cathodes. The tolerances of R_{15}, R_{16} and R_{17} should be not less than 5%, and for preference they should be 2%. In any case, R_{15} and R_{16} need to be matched to within 2% of each other. Similarly, although the anode loads R_{12} and R_{13} need not be close-tolerance values, it is advantageous for them to be closely matched.

The antiphase output from V_2 is fed to the Brimar 6BW6 output valves via capacitors C_{12} and C_{13}. Grid stoppers R_{18} and R_{19} prevent any tendency to parasitic oscillation in the power output stage. It is important that the 6BW6's are operated at a maximum h.t. voltage of 285 volts. If this value is exceeded there is danger of damaging the valves due to excessive screen current. Separate cathode bias resistors and bypass capacitors are used in preference to a common cathode resistor in order that slight adjustment can be made to either R_{22} or R_{23} to match out the standing anode current through the output transformer primary. These resistors have nominal values of 260Ω, obtained by connecting 330Ω in parallel with 1.2kΩ for each. Adjustment can then be made by using a higher or lower value in place of the 1.2kΩ branch so that a voltmeter connected across the output valve anodes reads zero at balance.

Negative feedback is taken from the output transformer secondary to the cathode of the

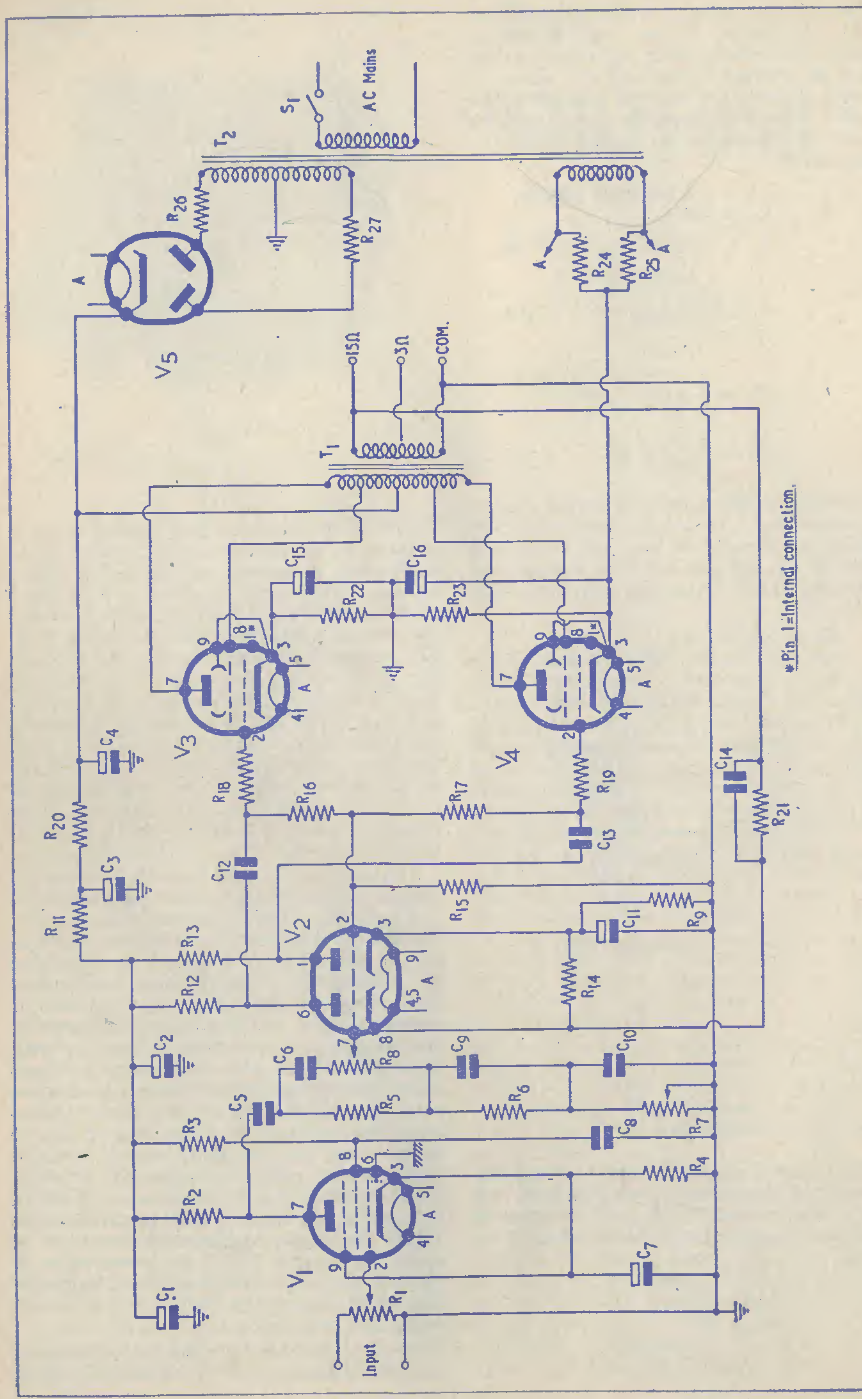


FIG. 1. CIRCUIT OF THE VIRTUOSO AMPLIFIER.

LIST OF COMPONENTS

R_1	500kΩ pot, log law
R_2	470kΩ ½W carbon
R_3	1.8MΩ ½W carbon
R_4	4.7kΩ ½W carbon
R_5	200kΩ ½W carbon
R_6	43kΩ ½W carbon
R_7	2MΩ pot, linear
R_8	2MΩ pot, linear
R_9	1kΩ ½W carbon
R_{10}	47kΩ ½W carbon
R_{11}	10kΩ ½W carbon
R_{12}	220kΩ ½W carbon, 5%
R_{13}	220kΩ ½W carbon, 5%
R_{14}	200Ω ½W carbon
R_{15}	220kΩ ½W H.S. 2%
R_{16}	220kΩ ½W H.S. 2%
R_{17}	270kΩ ½W H.S. 2%
R_{18}	1kΩ ½W carbon
R_{19}	1kΩ ½W carbon
R_{20}	4.7kΩ 2W carbon
R_{21}	1kΩ ½W carbon, 5%
R_{22}	260Ω 1W carbon, 5%
R_{23}	260Ω 1W carbon, 5% (330Ω in parallel with 1.2kΩ)
R_{24}	47Ω ½W carbon
R_{25}	47Ω ½W carbon
R_{26}	See text
R_{27}	See text
C_1, C_2	8+8μF 450V TCC CE27P

C_3, C_4	32+16μF 450V TCC CE/28PE
C_5	0.02μF 350V TCC CP33N
C_6	40pF mica TCC SMWN
C_7	100μF 6V TCC CE17A
C_8	0.05μF 350V TCC CP35N
C_9	200pF mica TCC SMWN
C_{10}	0.004μF mica TCC SM3N
C_{11}	100μF 6V TCC CE17A
C_{12}	0.02μF 350V TCC CP33N
C_{13}	0.02μF 350V TCC CP33N
C_{14}	0.001 mica TCC SM2N
C_{15}	50μF 12V TCC CE87B
C_{16}	50μF 12V TCC CE87B
V_1	Brimar 6BR7
V_2	Brimar 12AX7
V_3, V_4	Brimar 6BW6
V_5	Brimar EZ80/6V4
T_1	Output transformer (see text)
T_2	Mains transformer, Primary 200/230/250V. Secondaries, 6.3V 2A, 300/0/300V 80mA
S_1	On-off toggle switch

Miscellaneous items: 5 valveholders B9A, plugs and sockets for input, output, and mains voltage adjustment. Tag strips, nuts, screws, wire, etc. Mains plug and socket, Bulgin P73. Panel Sign transfers. Chassis 10in × 8in × 2½in.

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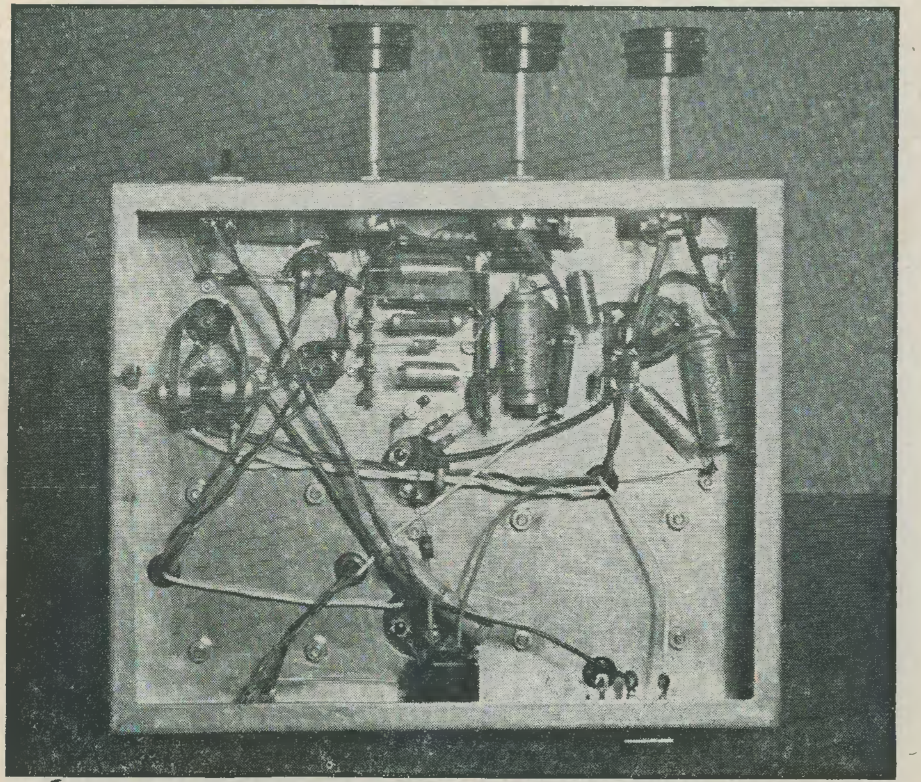
first section of V_2, via a phase correction network consisting of R_{21} and C_{14}. The values of these two components are not critical, but if other values than those specified are used, they should multiply to 1.0. It will be seen from Fig. 1 that R_{21} in ohms, multiplied by C_{14} in microfarads, is $1,000 \times 0.001 = 1.0$. This simple network has the effect of increasing the high frequency at which the amplifier loop gain is likely to run into positive feedback due to phase change.

When this amplifier was designed and built some three years ago the distributed load (or so-called ultra-linear) configuration for output stages was much less popular than it is now, and suitable output transformers were not so readily available commercially to the extent they are today (see addendum). It was, therefore, necessary to design and make a suitable transformer, details of which are given later for those who would like to copy it. In those days, too, there was little information in the popular literature concerning the optimum tapping point in the primary sections to which the screens are connected, although some sources had expressed the view that not all valve types required tapping in at the same point. In the prototype transformer, several primary taps were brought out for experimenting, and the feature has been retained so that feed points for the screens can still be altered if needs be.

The overall effect of altering the screen tapping point affects the output stage characteristics in several ways at once, and it is not at all easy to show mathematically just what happens. Graphs of different parameters, obtained by measurements, reveal that for a particular type of valve there is an optimum tapping point at which the valve is working partially as a triode and partially as a pentode. The valve will then assume the high gain of a pentode and the comparatively low distortion of a triode, and will be working at optimum points on parameters for intermodulation distortion, output damping factor, and power output.

It will, perhaps, be seen fairly readily that if the screens are connected directly to the primary centre-tap, or h.t., the valves will be pentode connected, and will operate as such. At this point none of the primary load is distributed to the screens, and there is no feedback to them. If the screens are taken to the outers of the primary, the valves will obviously be triode connected, and will tend to function as triodes. In this condition the primary load impedance is distributed to the screens equally, and there is maximum feedback. At various points between the centre tap and the outers of the primary, different values of primary impedance will be distributed to the screens as the tapping points are made at various places. If the tapping points are moved from the outer ends towards the centre tap of the primary, the valves will change their characteristics from triode to pentode, taking up a different parameter of partial triode/pentode at each point. The transition from triode to pentode mode will thus reach an optimum point when the distributed load produces points where parameters for all characteristics are passing through their slowest rate of change. It is at this point that the fullest advantage of the ultra-linear configuration is gained, and it is usually found that the power output of the stage is about 65–70% of that realised in the pentode condition. This loss of output is inevitable, but in the present design it is nearly all recovered by the positive feedback applied to V_2.



Underneath view of the "Virtuoso" amplifier

The design of transformers suitable for this type of output stage is a little more complex than for ordinary output transformers owing to the necessity to sectionalise the windings in order to keep the resistance of sections balanced as nearly as possible. In addition, interleaving of primary and secondary sections presents more of a problem if leakage inductance and inter-winding capacitances are to be kept to a minimum. The design given in the Appendix, though not ideal, largely takes these factors into account and produces a component that is within the abilities of most people who like to construct their own transformers.

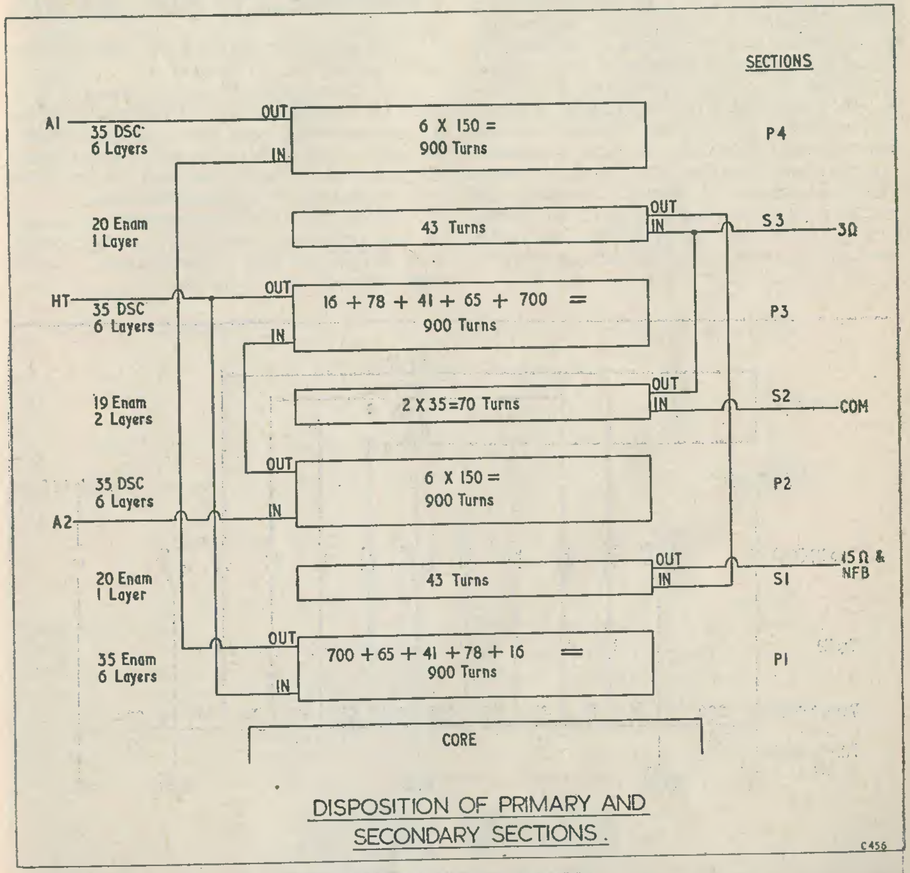
The optimum anode-to-anode load of the output stage is $8\,\text{k}\Omega$, and the secondary is designed to feed either a $3\,\Omega$ or a $15\,\Omega$ speaker. Negative feedback voltage is derived from the whole of the secondary winding. Screen tapping points are brought out at 15%, 18%, 20% and 24% of the primary impedance, for the reasons stated earlier. If a single screen tapping point only is required, the best one to choose is that for 18%. This gives the most favourable all-round performance with 6BW6 valves.

Passing now to the rectifier, a Brimar EZ80/6V4 is used for full-wave rectification.

A minor circuit simplification is achieved by being able to run the heater from the same winding that feeds all other valves in the amplifier, due to the high heater-cathode rating of the EZ80. Limiting resistors R_{26}, R_{27} are desirable for two reasons; one, that they prevent the surges during the charging time of C_4 from damaging the emission of the rectifier, and two, they form a convenient means of adjusting the rectified h.t. voltage to the required 285V maximum. Perhaps the best way to find the correct values is to use two $500\,\Omega$ wire-wound variables, which are adjusted to provide equal a.c. input voltages to the two rectifier anodes, at the same time noting that the rectified voltage is correct. The resistance values thus found, by measurement, can then be replaced with suitable fixed wire-wound resistors of adequate wattage rating.

The valve heaters are given a positive bias with respect to earth to assist hum reduction. This is particularly effective for the input stage, V_1, where hum is often readily induced but difficult to remove. The bias is obtained by connecting the centre-point of the heater winding to a source of positive potential, in this case the cathode of one of the output valves. Resistors R_{24}–R_{25} provide an artificial centre-tap for the winding, but they will not be needed if a centre-tapped heater winding is available on the transformer.

Resistance-capacitance smoothing is used throughout, thus saving the cost, weight, and space requirements of the more usual inductance-capacitance filtering. The output stage is supplied with relatively unsmoothed h.t., but proper balancing of the two valves effectively cancels out hum voltages present at that point. A certain degree of smoothing is obtained by virtue of the reservoir capacitor C_4 for the output stage. Two stages of filtering consisting of R_{20}–C_3 and R_{11}–C_2 reduce hum on the h.t. feed for V_2 to negligible proportions, and a further stage of filtering for the input stage V_1 is provided by R_{10}–C_1.



DISPOSITION OF PRIMARY AND SECONDARY SECTIONS.

Construction of the amplifier should present no problems, since normal practice is followed. Heater wiring should be run in twisted pair dressed close to the chassis, and kept clear of grid circuit wiring. Short earth leads taken to common points for each stage were found sufficient to ensure satisfactory hum-free operation. Use is made of tag strips to mount or anchor small components conveniently. After the heater feeds, h.t. wiring and mains transformer wiring has been completed, the components for the tone control network should be wired, for they are then more accessible.

When switching on the amplifier for the first time it is necessary to ensure that the negative feedback connections on the secondary of the output transformer are correct. If a loud howl begins to develop as the amplifier warms up, it should be switched off immediately. Reversing the secondary winding connections as given in the Appendix should ensure correct feedback. If there is residual hum present, earthing the chassis should effectively remove it, though normally the amplifier can be run without an earth. Finally, never use the amplifier without a speaker connected, otherwise damage may be caused to the output valves.

Acknowledgements

The author wishes to thank Mr. Manners of the Valve Application Department, Standard Telephones & Cables Ltd. (Brimar Valve Division), and Mr. Barnes of the Radio Division, The Telegraph Condenser Co. Ltd. for their helpful advice and assistance. Thanks are also due to Mr. J. L. Warne for the photographs illustrating this article.

APPENDIX I

Output transformer secondary connections. If self-oscillation develops with the connections of diagram A they should be reversed to those shown in diagram B, and vice versa.

APPENDIX II—WINDING DETAILS OF OUTPUT TRANSFORMER

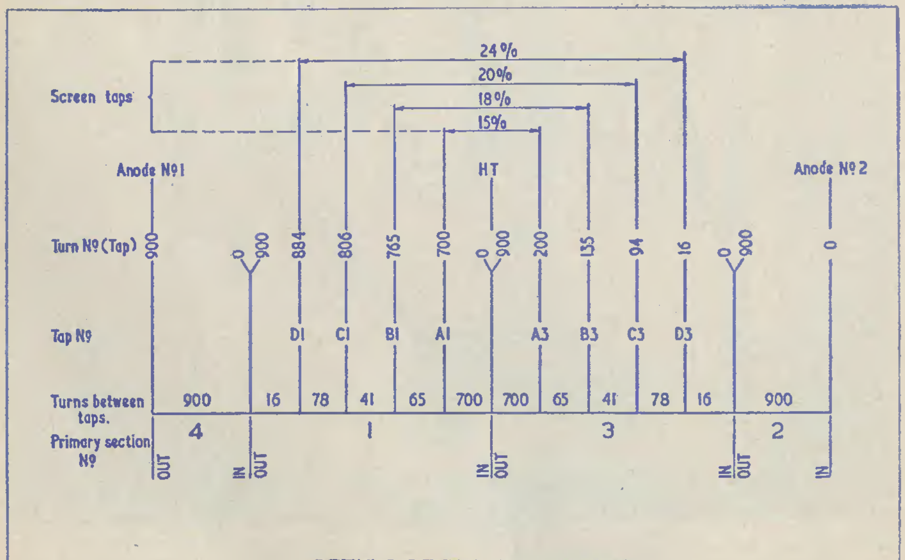
Core: 1in stack of 1¼in waste-free type stampings.

Tappings: At 15%, 18%, 20% and 24% of primary impedance for output valve screen grids.

Total secondary winding for 15Ω speaker, with tapping for 3Ω speaker.

Brief specification: Primary wound in four sections interleaved with secondary sections. Layers separated with one turn 1-mil paper, sections separated with two turns 5-mil Empire cloth. Two turns 5-mil Empire cloth over completed winding to finish.

Primary leads and taps brought out on end of one coil-cheek, secondary leads brought out on opposite side of same cheek, i.e., *not* opposite ends of coil layers.



DETAILS OF PRIMARY WINDING

All windings in same direction.

Winding details: Primary, section No. 1. Total 900 turns 35 swg. DSC in 6 layers, 150 turns per layer. Taps brought out at (A1) 700th turn, (B1) 765th turn, (C1) 806th turn, (D1) 884th turn from commencement of the winding, leaving 16 turns to end of winding.

Secondary, section No. 1. Total 43 turns 20 swg. Enam in one layer.

Primary, section No. 2. Total 900 turns 35 swg. DSC in 6 layers, 150 turns per layer, no taps.

Secondary, section No. 2. Total 70 turns 19 swg. Enam in 2 layers, 35 turns per layer.

Primary, section No. 3. Total 900 turns 35 swg. DSC in 6 layers, 150 turns per layer. Taps brought out at (D3) 16th turn, (C3) 94th turn, (B3) 135th turn, and (A3) 200th turn from commencement of the winding, leaving 700 turns to end of winding.

Secondary, section No. 3. Total 43 turns 20 swg. Enam in one layer.

Primary, section No. 4. Total 900 turns 35 swg. DSC in 6 layers, 150 turns per layer, no taps.

Windings to be inter-connected as shown in diagram.

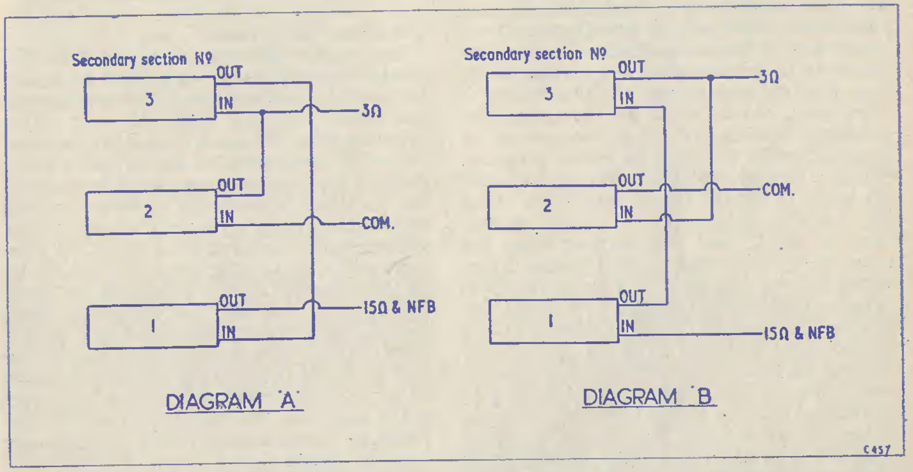


DIAGRAM 'A'

DIAGRAM 'B'

ADDENDUM

Since this design was prepared some manufacturers have produced transformers for use in ultra-linear output stages. From data kindly supplied by Messrs. R. F. Gilson concerning their range of output transformers, some types are seen to be suitable for the Virtuoso, and could be used by those who do not wish to make their own transformer. No opportunity has arisen to test these transformers under working conditions, but a study of the published data reveals no reason why they should be other than entirely satisfactory.

Type WO.710/8K is rated for 8,000Ω primary load, with screen taps at 43% of the turns ratio. Secondaries are rated for 2× 3.7Ω and 15Ω. Primary inductance is of the order of 140H. This transformer is primarily for use with EL84 valves, which suggests a power handling capacity of some 15W. The price is £2 12s. 6d.

Type WO.710 is rated for 7,000Ω primary load, with screen taps at 20% of the turns ratio. In other respects it is similar to the WO.710/8K and is primarily for use with the Osram 912 amplifier. Its use with the Virtuoso may result in slight distortion due to the mismatch of primary load and the lower value of screen drive. The price is the same.

Type WO.892 is similar to the WO.710/8K, but with a slightly higher primary inductance of 180H. The power handling capacity is not stated, but it would not be likely to be lower than 15W. The price is £3 2s. 6d.

For Your Workshop

J. Stead & Co. Ltd., Manor Works,
Cricket Inn Road, Sheffield 2

Steadfast Hacksaw Frame in a plastic wallet

Incorporates an entirely new type of transluscent amber plastic handle. This handle gives a better grip, and in conjunction with the adjustable oval tube frame, forms a beautifully balanced tool of very robust manufacture. The frame is sold complete with a 12in × 24T Steadfast Regular Tungsten blade, and is fitted into an attractive transluscent plastic wallet, in which there is also an additional 12in × 18T blade. A booklet describing the correct use of a Hacksaw is enclosed in the wallet. Retail price 19/6 each. Available from ironmongers, tool merchants, garages, etc.

radio miscellany

centre tap . . . *talks about items of general interest*

On a number of occasions in post-war years I have raised a mild protest at the use of the word "ham" to describe a licensed transmitting amateur. It has too many derogatory connotations ranging from ham-fistedness to ham acting. There is nothing against its use when limited within the radio fraternity, but unhappily it is only too often used in a contemptuous sense—particularly by smugly superior types.

Another unfortunate instance of the use of the term "ham" was evident recently. I am sure this particular user did not intend it offensively, but its effect on the rather disparaging attitude of some hearers to a scientific hobby was none the less unfortunate. Whilst watching the I.T.V. Play of the Week "A Voice in Vision" (based on the life of the late John Logie Baird), I suddenly recalled that the B.B.C. was that evening using full aerial power from the Crystal Palace transmitter for the first time. As the programme being radiated at that particular moment was international amateur boxing, I found myself wooed away from I.T.V. for a quick look. At that particular moment the commentator was doing his between-the-rounds stuff. He mentioned that the Dutch boxer (a champion in his own country and the eventual winner of the bout) was not only a radio technician by trade who wore glasses outside the ring, but that he was also a "week-end" short-wave radio ham. Left at that no one would have taken much notice, but unfortunately he added that even if he was a ham at radio he was proving himself no ham when it came to a matter of boxing!

The word ham," as applied to a radio amateur, has become so widely accepted that it is no longer possible to live it down. Nevertheless, I feel it should be studiously avoided when discussing the hobby with the non-radio-minded. Those associated with any aspect of the hobby for long know only too well that their non-technical neighbours instantly attribute every bang, crash or buzz that emanates from their radio, or every fault that appears on their "telly" screen, as being due to that "chap fiddling with wireless experiments." The word ham is also introduced—to imply clumsy, blundering inexpertness. There is quite enough unreasonable prejudice against radio amateurs by ignorant and difficult neighbours as it is—and there seems to be at least one of this sort in every group of twenty or so houses. We ourselves, even in more amiable company, should be the last to be guilty of lessening the dignity of radio as a hobby by careless talk.

Old Dog, New Trick

Early after the war when ex-W.D. $1\mu F$ Mansbridge type capacitors could be bought for a copper or two a dozen, a few enterprising gentlemen wrapped them in neat labels extolling their virtues as "Capacity Aerials," and sold them like hot cakes at half a crown each. True they gave some result as an aerial, but the signal pick-up was no more than that obtainable with a very short length of wire. However, the demonstration given by street and market traders appeared very convincing as they touched one lead against the aerial socket of a live set. A moistened finger against the aerial socket would give equally good results. The unsuspecting public were not to know that. They cheerfully parted with their half-crowns only to find, when they got home, that the capacity aerial so convincingly demonstrated gave a lot less signal than the tiniest indoor aerial.

I always find it amusing to hear the demonstrators shoot their line about the "purer" tone, freedom from atmospherics and jamming, obviating the need for unsightly wiring and strongly stressing that every one was "stamped and ramped" tested at 250 volts. I never cease to marvel at the gullibility of the public. Was it Barnum who said: "There's one born every minute"? Capacity aerial purchasers seem to be born at about the same rate.

Last week I saw one of these wily salesmen who had developed a new technique. Holding up a length of moth-eaten single flex he cried, "This is the sort of stuff most people use for an aerial—'ung around the pitcher-rail." Holding the end of the flex against the aerial socket he continued, "See 'ow it be'aves compared with this." A very weak signal emanated from the loud-speaker. "Now for the Capacity Aerial," he went on. Touching it on the aerial socket a roaring signal rang out. The half-crowns rolled in faster than I have ever seen before. How was it done? My guess is that the moth-eaten flex was severed an inch or two along its length and the demonstrator carefully kept his fingers on the insulated part so there was practically no signal input. I am wondering what is going to happen to the sales if one day he accidentally connects up the wrong end of the flex and gets a lot better signal than the Capacity Aerial gives.

Tip

Incidentally, a Mansbridge type capacitor will make a first-class indoor aerial—if you undo the foil and drape it around the room! It has the virtue that it can be completely concealed behind the wallpaper or frieze. I have a foil f.m. dipole. I secured a length of frieze to match that already adorning the wall and cut it to correspond with the pattern. The foil was sandwiched behind it as it was stuck down. The ends were folded several times and then gently riveted to transparent twin line. The latter is nearly invisible when neatly pinned to the wall on its way down to the set. It is, of course, necessary to pin teh lead-in securely to the wall as there is no mechanical strength to the foil or to the connections. By the way, leave the waxed paper on, or better still, use both layers of foil as well as the waxed "dieletric" paper for maximum strength.

Disc Spinning

One or two more interesting letters have turned up re the best bargain in test-cum-enjoyment extended play records. It is rather odd how this column's interest in records has coincided with their rocketing sales. Stranger still, we have concerned ourselves with 45 r.p.m. records, and these have shown the biggest increase. From the five million mark in the previous year, 1957 sales leapt to ten million. As they carry 60% purchase tax on the *wholesale* price it must be very good business—for the Government!

Most of the correspondents, too, mention a preference for 45 r.p.m. discs. They like the compactness, toughness and the fact that the purchase of one record occasionally does not make too big a hole in one's pocket. Of long-plays, one reader says: "A couple of pounds is too much for one record. It's the price of three or four valves! Anyway, they play *too* long, especially now almost every gramo is fitted with an automatic changer!" On the subject of automatic changers, another asks: "Why cannot more records be made so Part 3 backs on Part 1, and Part 4 on Part 2? Then one could play them in their proper sequence—only needing to stop and turn over once."

So far I have not had two recommendations for the same record. Nor has anyone yet written to say that they have bought a readers' recommendation and been disappointed with it. I've been fully expecting to hear from someone saying so-and-so's choice may be all right as a test record but if he thinks it is pleasurable listening, then he ought to have his head examined!

The Music Goes Round and Round

Owing to my recent illness I have not been able to hear all the new suggestions. Letters, however, contained several points of interest. F.J.W. (Wolverhampton) suggests a panel from the Editorial Staff should select the outstanding record of the month He thinks it would interest hundreds of readers—and those mad on all-constructional issues would not be inconvenienced by more than the loss of an inch or so of space.

R.D. (Chester) says he cannot add to the discussion as he is a "specialist" record buyer. He buys only ballet music records. By closing his eyes he can imagine the loveliness of colour and movement conceived by the composer. To have to see the dancers destroys, for him, all the beauty and grace of the music. He would be interested to hear of "undiscovered treasures" in the lesser-known ballets.

J.G. (Crowley Heath, Rickmansworth) puts forward Strauss's *Unter Donner und Blitz*, Philadelphia Orch. (Philips NBE11060). I have not caught up with this one yet, but believe it is a very recent recording. I can well imagine that the "Galop" sounds terrific. He writes: "The drums are staggering and, apart from its wonderful test qualities, it is a marvel of precision playing." He also recommends Gounod's *Faust* (ballet) by the Boston Promenade Orch. (HMV 7EP7027) as being a lovely record with excellent dynamic range and jolly good value for money. I can confirm that our Aberdonian friend should very nearly get his full money's worth in settling for this one. It has nearly everything.

F.P.P. (Beckenham, Kent) and C.W.M. (Iver, Bucks) mention the Cosmocord 45 r.p.m. Test Record. As one side of this

(*continued on page 498*)

Technical Forum

Rumble in Hi-Fi Systems

It is perhaps axiomatic that the better a sound reproduction system is made, the more obvious are its defects. For example, a system which has been in use for some years may be fitted with an improved type of loudspeaker which can immediately show up some defects in the amplifier which had hitherto passed quite unheard. Any such change in the equipment may be aimed at improving the bass response, but the results can so easily be disappointing because of the presence of low frequency rumble. The cure for this trouble is not to generally degrade the bass response, as a good reproducer with inadequate bass can sound "thin" and the music loses much of its realism. Listening tests will prove that if the response is poor in the lower frequencies it is necessary to attenuate the high frequency performance in order that a more balanced result can be obtained. It is a little surprising, but nevertheless true, that it is easier to achieve a good top response in a high fidelity system than it is a good response at the lower end of the scale. In fact, the relatively high price of good quality amplifiers and speakers is largely due to their having to have a better than average bass performance. However, having achieved this, rumble may show up in one of its several forms.

Detecting Rumble

How, then, can rumble be detected? In its most obvious form the trouble shows up as what may be described as a very low frequency rattling noise—this being particularly annoying when the amplifier is working at relatively high volume levels. More usually the rumble frequency is of a somewhat lower order; and it may be below audibility, in which case it can only be heard by the effect which it has on the reproduction. Some time ago in these pages we discussed a defect known as intermodulation distortion, and it was shown that various components of the music being reproduced would beat with one another, thereby producing additional components which were not present in the original. For this to occur, some amplitude non-linearity has to be present, and therefore it is most likely to be heard on the lower frequency components of the music which are usually of much greater amplitude and duration than the higher frequencies. As already stated, rumble may be present at a sub-audible frequency of quite large amplitude, and may produce intermodulation with the lower frequency components in the reproduction. To the listener this will appear as a general lack of clarity in the bass region, and will become worse as the volume level is increased.

Another rough check which is often applied to detect the presence of rumble is to suspend a piece of tissue paper in front of the loudspeaker and note its movements. If it seems to move in a manner which has no apparent connection with the music being played, it is a sure indication of rumble.

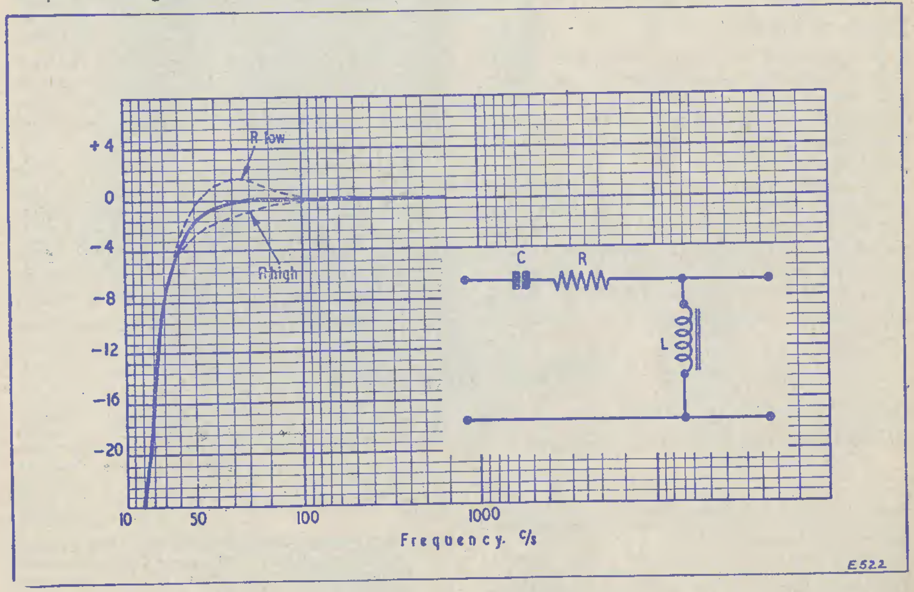
Causes of Rumble

Having detected the trouble, the next problem is to find its cause, as quite often an appreciable improvement can be obtained without resorting to filters in the amplifying systems. The motor and turntable are the first items to be suspected. Any roughness in the rotor bearings or in the final drive to the turntable may cause trouble. With units in which a hard rubber driving wheel is used to engage the inner rim of the turntable, both the rim and the wheel should be examined for "flats" on their working surfaces. These flats may be found if at any time the turntable was stopped whilst the motor was still driving it. If the driving wheel is not in perfect condition it should be replaced by a spare obtained from the manufacturers. Rumble arising from these causes can often be heard on the unmodulated grooves of L.P. records.

Slight rumble arising from other causes may be magnified by resonance in either the tone arm or stylus: such resonances usually appear below 50 c/s, and in the better class equipment the designer will have taken steps to reduce the possibility of it occurring as far as is practicable.

Unfortunately there is some low frequency noise on all recordings, and the writer has also heard records which have rumble recorded on them due to imperfections in the manufacturer's equipment.

The last main cause of rumble which is all too often present when playing the slower speed recordings is due to mechanical feedback between the speaker and pick-up. This feedback can occur in equipments where the speaker is mounted in an entirely separate cabinet to the record player and may even be located in a different corner of the room. An indication of whether this trouble is occurring may be obtained by placing a hand lightly on the cabinet which houses the player and noting whether vibration is detectable on the louder sound passages. An appreciable improvement is generally obtained by making use of some form of resilient mounting for the motor board. With the more persistent cases it may be necessary to resort to a rather more complex arrangement. In this the motor board is rigidly bolted to the wooden top section of the cabinet, this latter then being resiliently mounted within the cabinet. This increases the mass and reduces the basic vibrational frequency of the motor and board. A still further reduction is possible by the addition of short strips of lead firmly attached to the underside of the board.



Typical circuit values are:
$C = 2\mu F$, $L = 4H$, *and* $R = 510\Omega$

A Rumble Filter

If for any reason after the above-mentioned points have been attended to some rumble still persists, a low frequency filter must be added to attenuate the bass response of the amplifier. Ideally the inclusion of the filter should not alter the response above 50 c/s but should produce an attenuation of around 12db per octave below this frequency. Single or two-stage R–C filters are not in themselves satisfactory because they are insufficiently selective and, therefore, provide too much general bass attenuation. Where they are employed successfully they are used in conjunction with some system of feedback. Perhaps the simplest and one of the most successful type of filter consists of an L–C–R combination between the pick-up and amplifier. No modifications are required to either unit, and the filter can be made small and easily connected into circuit. The graph shows the response obtained from such a filter, with the circuit diagram inset. The efficiency of this type of filter depends entirely on the inductor, which must have the highest possible Q at low frequencies. This is achieved by using a low-loss core of radio metal or similar material and employing the largest diameter wire consistent with the required inductance on the chosen core size. The types of core used on the high quality P.U. matching transformers prove ideal for the job. The relationship between the various components in the filter is given by two formulae:

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

$$R = 2\pi f L$$

The effect of increasing or decreasing the resistor value for any chosen cut-off frequency is shown by the dotted response curve.

It is very essential that the complete filter be very adequately screened, particularly from magnetic fields which would interact with the choke. The complete unit is usually housed in a separate steel box fitted with two coaxial sockets, one for input and the other for the output lead. As a refinement, a switch may be included to cut the filter out of service on recordings where it is not required.

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radio miscellany

(*continued from page 495*)

consists of fourteen test frequencies (50 c/s to 10 k/cs) it hardly meets the original specification on the score of entertainment value. However, the other side has five musical passages specially selected for full range test. C.W.M. rightly reminds me that the test frequency side produces some startlingly revealing results on "good" equipment. In fact, I can well imagine half our readers tearing down their amplifiers and re-building, then rushing off to buy new speakers!

Return of Thanks

On behalf of the Editor, Staff and also for myself—our warmest thanks to all readers who were good enough to send cards at Christmas. It is nice to feel that so many look on us as old friends rather than a mere business organisation.

As usual there were some novel cards combining various aspects of the hobby with festive greetings. My old and unknown friend who for years sent me cards with Ye Snow Covered Olde Worlde Cottages on which were drawn an untidy tangle of t.v., f.m. and long wire aerials from every chimney pot and tree-top, missed out. I hope nothing has happened to him!

Perhaps the best of the DX was a card from KL7DR (Alaska). It was perfectly timed—arriving as it did on Christmas morning. A nice thought was the club card from members of the Derby and District Amateur Radio Society. From the *Hi-Fi News*, too, came a card with a straight through aerial to earth bearing a "down-to-earth wish." A message also from Old Timer G8IX who, despite many years "retirement" from the hobby, got so absorbed in reading the December issue that he spent most of Boxing Day with it. He then re-read it next day! Let's hope he will be stirred into activity again, especially as a few passages from this column revived sentimental memories for him.

Letters bringing forward interesting points were also received, especially those from J.C. (Bromley), A.S. (Prittlewell) and T.S.D. (Blackrock, Co. Dublin). Sorry, chaps, if circumstances have prevented me from replying to them all, but I hope next month to find space for some of the points raised.

Book Reviews

FUN WITH RADIO. By Gilbert Davey. 64 pages, 34 diagrams. Published by Edmund Ward (Publishers) Ltd., 194–200 Bishopsgate, London, E.C.2. Price 10s. 6d.

The contents of this book have appeared from time to time as articles in *The Boys' Own Paper*. It contains fourteen chapters in which are described several simple designs for radio receivers that the young enthusiast can build for himself.

Commencing with crystal sets, the book proceeds to present a series of receivers from single valve sets to a five-valve superhet. The instructions are clear, and it is to be noticed that the possible dangers of mains operation are stressed in several places, particularly for the a.c /d.c. type of receiver.

There are a few points upon which one could level some criticism. Those designs using reaction on the first stage are not good practice, especially when such receivers are in the hands of inexperienced youngsters, since widespread interference due to self-oscillation can occur.

The use of plug-in coils has rather gone out of fashion, so it is thought some of the designs specifying them could have been presented by using sets of coils wired to range switches. The author's statement that he used, in some instances, components he had on hand is not much help to the reader when he finds that these particular items are no longer available. Suitable alternatives should have been specified.

Three of the receiver designs specify obsolete 2-volt valves. Apart from the difficulty of obtaining and running such valves, it would have been to advantage to indicate suitable alternatives in the miniature 1.4-volt range.

W. E. THOMPSON

THE TELEVISION ANNUAL FOR 1958. Edited by Kenneth Baily. 160 pages, 177 illustrations. Published by Odhams Press Ltd., 96 Long Acre, London, W.C.2. Price 10s. 6d.

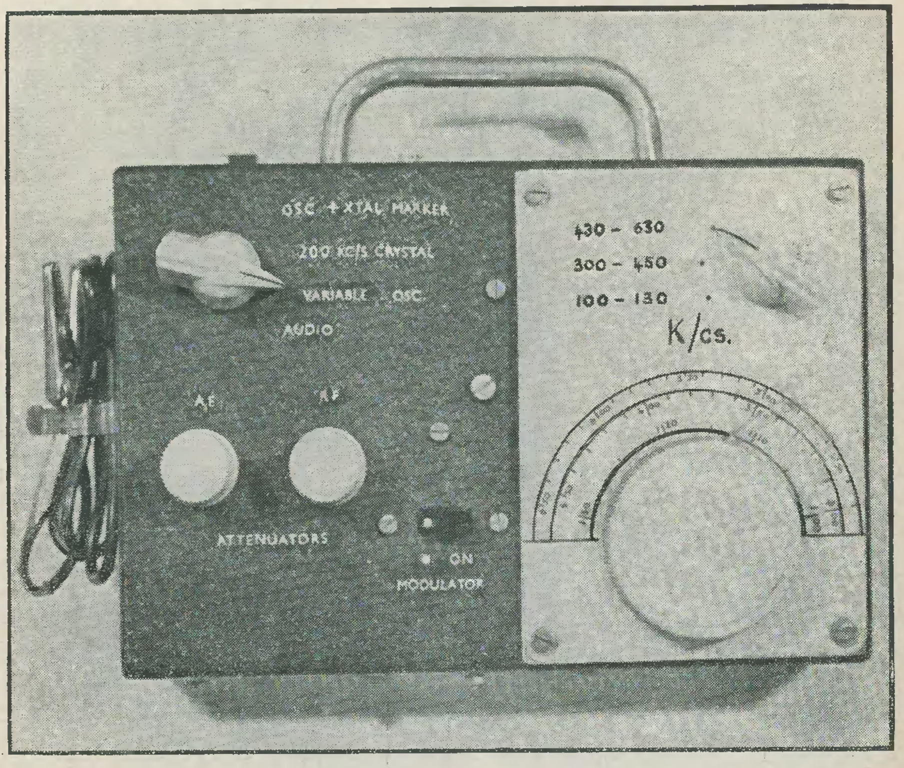
What goes on behind the scenes to produce the many popular television features, and information about the host of celebrities, can always make interesting light reading. In this book there is much to entertain the reader in this direction. The text is profusely illustrated with good photographs depicting many scenes from the programmes, together with portraits of favourite stars.

It is not possible to single out here particular articles for individual comment, for the simple reason that there are so many of them. The index reveals that the book contains articles and pictures in great number, and for the price charged for it the book can provide many hours of pleasant reading. Many of the articles have been contributed by well-known names in the world of television.

W. E. THOMPSON

TEST INSTRUMENTS

A Transistorised Crystal Checked Service Oscillator



by **DENNIS W. AVARD, G3IEY**

Facilities

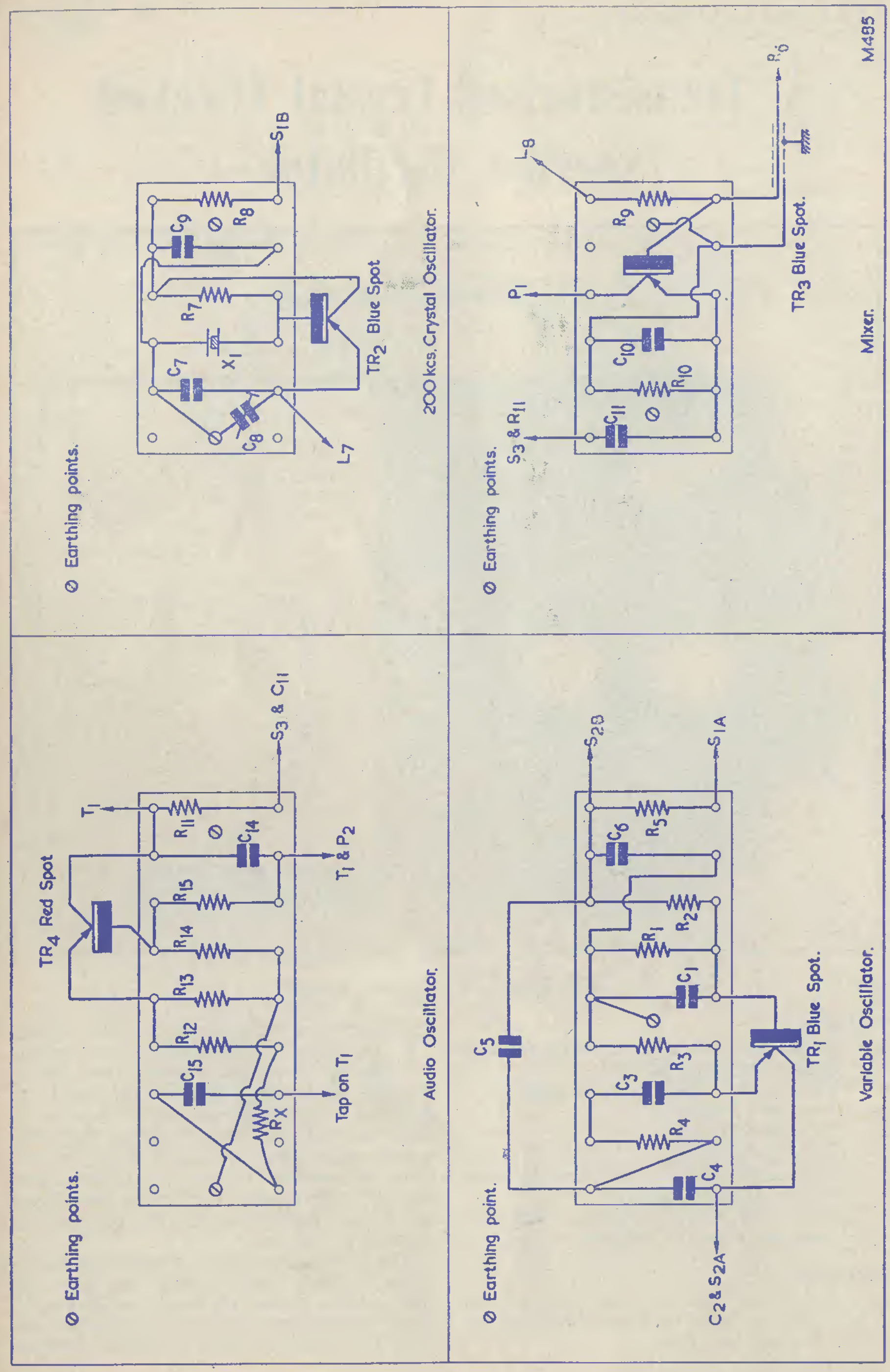
- Audio Oscillator approximately 650 c/s.
- Crystal Oscillator 200 kc/s.
- Variable R.F. Oscillator, 3 ranges;
  - 100–130 kc/s
  - 300–450 kc/s
  - 430–650 kc/s.
- Modulation of R.F. Oscillators optional from Audio Oscillator.
- Ability to check Variable Oscillator against Crystal Oscillator.

Portability

- Size 7½in × 5in × 2in and powered by 2.6 volts from Mercury cells for stability and long life.

THIS UNIT IS THE OUTCOME OF THE AUTHOR'S experiments with transistor equipment. Being a service engineer and radio amateur, experience with transistors had to be obtained—if possible with something worthwhile at the end. After building the usual square wave generator and signal tracer (built respectively in two "Styptick" cases, and a shaving soap stick case), something more was needed—hence the tests which resulted in this unit.

The circuit comprises a variable r.f. oscillator covering those frequencies used for radio i.f.s; a crystal oscillator at 200 kcs, to check the variable oscillator and also provide fixed r.f. points; a buffer amplifier which is



Audio Oscillator.

Variable Oscillator.

200 kcs. Crystal Oscillator.

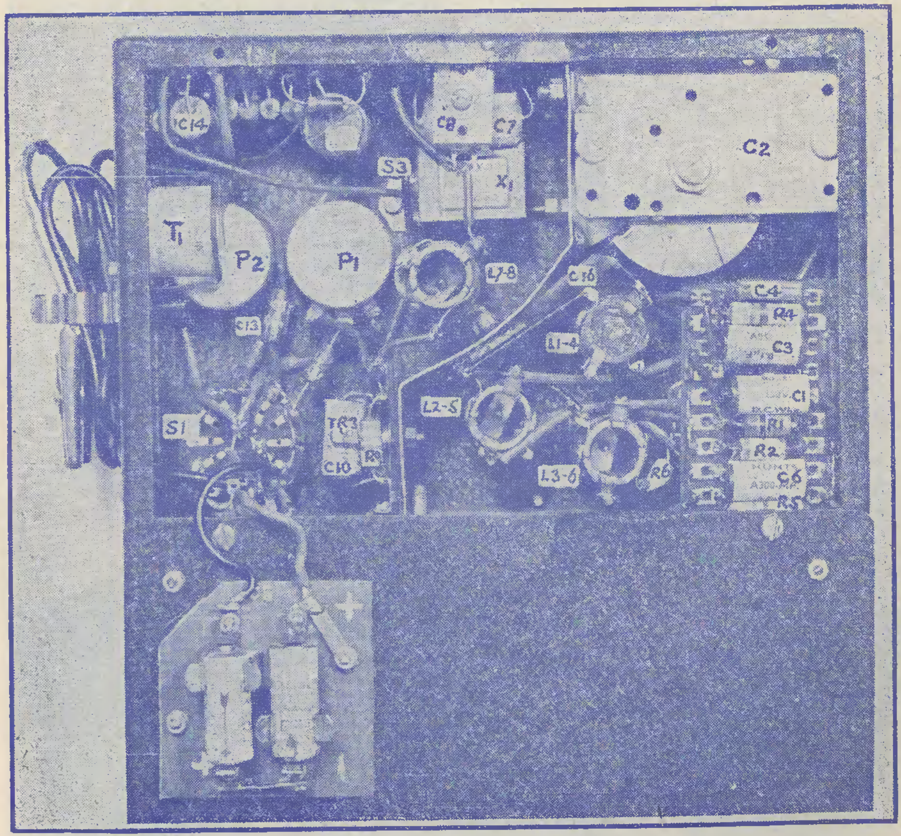
Mixer.

also used as a mixer when the r.f. oscillators are required to be modulated by the a.f. oscillator. The output from the a.f. oscillator is also available for a.f. tests.

The method of construction was to build the various stages onto "Radiospares" miniature tagboards; two 6-way boards for the crystal and mixer units, and a half each of an 18-way board for the variable and a.f. oscillators. These boards are then fitted in the metal case.

It will be seen (Fig. 1) that the variable oscillator is a modified Colpitts and the a.f. oscillator a Hartley. In the buffer mixer stage the r.f. is fed in on the base and the a.f. applied in the emitter. R.F. output, modulated or c.w., is taken from the collector. It was found necessary to utilise a mixer, as modulating the variable oscillator directly introduced an appreciable amount of f.m. as well as a.m.! The crystal oscillator circuit is due to Mullard Ltd., and will even work on a single cell for power.

In order to utilise standard components, some modifications have been necessary to two of them. L$_1$–L$_4$ requires a dust core to be cemented in it after adjustment of frequency coverage on the lowest range. Also T$_1$, a parallel fed autotransformer, has *all* but 4 of its "I" laminations removed. C$_{14}$ is used to determine the frequency of oscillation, but most of the components in this stage will alter it to some extent. The series feedback resistor R$_{12}$+R$_x$ is adjusted to improve the waveform—consistent with reliable operation. In this unit the waveform is a very good sine wave, marred only by a "pip" on the negative crest.



In this view showing layout, the lower back panel has been "let down" and held in position by screws for ease of photography

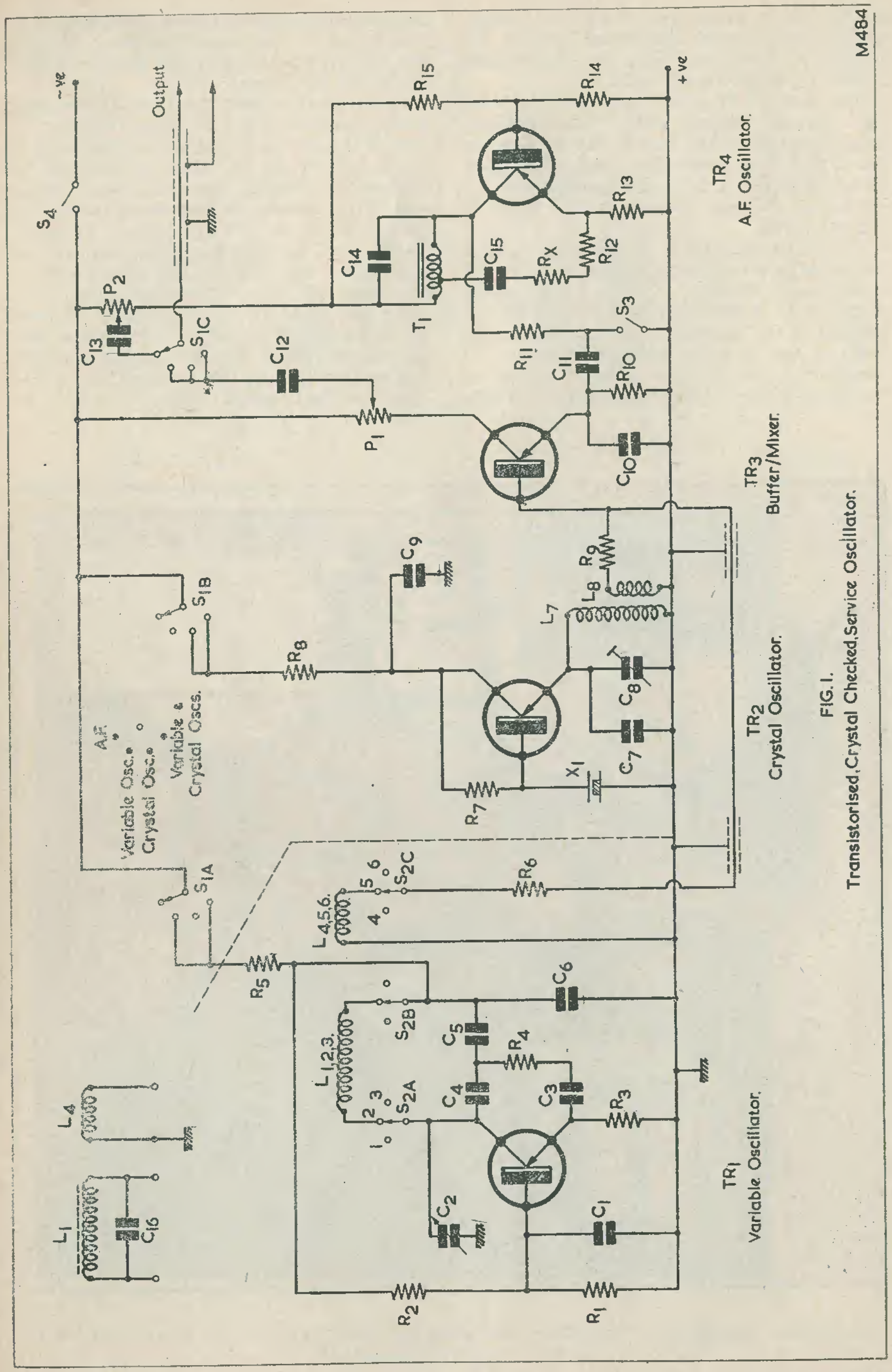


FIG. 1. Transistorised, Crystal Checked, Service Oscillator.

Over-driving the mixer will produce many spurious outputs, and this is prevented by the resistors R_6 and R_9. The performance of the variable oscillator is very pleasing. Short term stability is good, and day-to-day calibration errors, due to the temperature sensitiveness of TR_1, easily checked and allowed for by switching S_1 to "Crystal + R.F." and monitoring the output of the mixer with, say, an r.f. signal tracer and checking the beats of the two oscillators. In fact, it might be possible by making R_5 variable to reset the variable frequency oscillator to the tuning scale, but this has not been tried.

Harmonics, checked on a communications receiver, are detectable to over 7 Mc/s from the crystal oscillator, and on all three ranges of the variable oscillator to more than 4 Mc/s. Study of the L–C values in the variable oscillator would indicate resonance to be higher than the actual oscillator frequency at any given setting of the tuning control. This was a surprise at first, but it is realised that the phase shift in the transistor is the cause.

Battery consumption from two "Mallory" type RM401 mercury cells is phenomenally low, being A.F. Oscillator 500μA, mixer 10μA (undriven), crystal oscillator 260μA, variable oscillator 690μA. The two cells are held in small "Terry's" spring clips and connections are made by four "L"-shaped strips of copper, bolted to a Paxolin base. The tuning pointer is fabricated from a "Radiospares" 2-inch knob with a Perspex cursor cemented in a cut-out in the rim. When using the unit it is considered advisable to set the appropriate attenuator to zero when connecting or disconnecting, to allow the charging or discharging currents of the series output capacitors to flow through the battery rather than through the mixer and a.f. oscillator transistors!

Grateful acknowledgments are due to G. Smith, G3FZB, for his help in testing this unit.

Components List

$R_{1, 3, 12, 13, 14}$	1kΩ
$R_{2, 6, 15}$	4.7kΩ
$R_{4, 5, 8}$	470Ω
R_7	0.47MΩ
R_9	8.2kΩ
R_{10}	330Ω
R_{11}	27kΩ
R_x	about 1kΩ
All ¼ watt	
P_1	250Ω wirewound miniature
P_2	2kΩ wirewound miniature
$C_{1, 3, 6, 9, 10, 11}$	0.1μF paper
C_2	500pF 1 gang
C_4	350pF S.M.
C_5	120pF S.M.
C_7	300pF S.M.
C_8	100pF mica trimmer
C_{12}	0.001μF paper
C_{13}	0.01μF paper
C_{14}	0.02μF paper
C_{15}	1μF paper
C_{16}	300pF S.M.
All paper capacitors, Hunts small "Moldseal". Tuning capacitor, Jackson Bros. Type E.	
$TR_{1, 2, 3}$	Blue Spot
TR_4	Red Spot (all P-N-P types)
S_1	3-pole 4-way rotary function switch
S_2	3-pole 3-way rotary, range switch
S_3	S.P.S.T. slide, modulation switch
S_4	S.P.S.T. slide, power switch
T_1	Intervalve parallel feed auto transformer, Franklin
$L_{1, 4}$	Wearite PA1 +dust core
$L_{2, 5}$	Wearite PO1
$L_{3, 6}$	Wearite PA2
$L_{7, 8}$	Wearite PA1
X1	200 kc/s miniature crystal unit
Case, 7½in × 5in × 2in (Philpotts)	
1 × 18-way miniature tagboard and 2 × 6-way miniature tagboards (Radiospares)	

Magnetic Tape Recorders

MICROPHONES—*The Weakest Link?*

PART 2

By A. BARTLETT STILL

Last month we had a look at the characteristics of the crystal and condenser types of microphone, and before going on to consider the moving coil and ribbon forms of construction it should be noted that these types fall into two distinct categories. The two microphones previously discussed are basically high impedance devices and, as such, purely voltage generators. The electromagnetic types, on the other hand, are low impedance sources, as we shall see, and may be considered as current or power generators.

Moving Coil Types

A wide variety of moving coil microphones are available at prices from about three or four pounds. The system is ideally suited to a compact instrument, and it is not surprising that advantage has been taken of this to produce hand microphones for individual use of pleasing design. As mentioned earlier, three impedance versions are now generally available, but it is believed that the standard line impedance of 600 ohms is not popular with home constructors. It is proposed, therefore, to deal only with low and high impedance models.

A usual low impedance figure for a moving coil microphone is 25 ohms, and the sensitivity would be given as around −88db below 1 Volt/dyne/cm^2. This is where the confusion previously referred to can arise. The same microphone with an impedance of 50kΩ would be quoted as −54db. The second case takes into account the voltage transfer of the "input" transformer, whereas the first does not. These figures are representative of the type and show little difference from the crystal type.

The frequency response obtainable will, however, show a more marked variation. The average moving coil "desk" microphone will cover the approximate range 70–6,000 c/s, but "hand" models, having usually a smaller diaphragm, would probably have a response from 150 to 10,000 c/s. This can be compared with a crystal unit using a comparatively low value of input load resistor.

When it is required to use a longer line between the microphone and pre-amplifier, the advantages of a source impedance of only 25Ω will be obvious. Unless really long lines of 20 yards or more are considered, it is often not necessary to provide any screening for the cable. It must, however, be borne in mind that the d.c. resistance of the line should be low, to avoid insertion loss. A second advantage of the moving coil microphone, unique to the type, is that they are quite robust. While any microphone should be treated wherever possible like the instrument it is, dynamic units will stand a fair amount of knocking about.

Ribbon Types

Many tape recorder owners are known to consider that the possession of a ribbon microphone means that their ultimate aim has been achieved; they have the best. In many respects, of course, that is true; but it is a point of view that may be largely due to the higher purchase price, from eight to ten pounds upwards.

Although vast improvements have recently been made in this direction, the sensitivity of ribbon microphones is generally lower than that of the other types. The high impedance versions will normally range from −60 to −56db. Our "average man" speaking at three feet distance will only produce about 1mV at the grid of the pre-amplifier valve.

It is on turning to the question of frequency response, however, that the ribbon microphone shows such tremendous advantage over all other forms of construction. Not only do we get better response to the bass frequencies, but the treble response extends to 12 or 14 kc/s. Further, the response curve over that range is much cleaner and, on the more expensive models, may well be held to limits of ±2db.

It will be found that both 25Ω and hi-Z versions are available for the more popular makes, as with the moving coil. Unlike the moving coil microphone, the ribbon microphone is definitely a fragile instrument, and note must be taken that it is not suitable for outdoor use.

Finally, while other forms of construction are normally omni-directional, the ribbon microphone is inherently directional in its pick-up, having a "figure-of-eight" polar diagram.

. . . .

We have completed a general assessment, necessarily limited by space, of four different types of microphone. One of these, the condenser, begins to look like the "odd man out" already. Such types are not so readily obtainable, they are expensive if good quality is to be desired, and a similar performance can be obtained from other types which do not suffer from some of the disadvantages that arise with the use of a condenser microphone.

Such a dismissal, seemingly rather abrupt, should not be taken to indicate a personal dislike of condenser microphones on the part of the writer, nor should it be taken to mean that they are "no good." In fact, they are often used for instrument work. Their rejection is, however, a logical step in the circumstances we are considering.

It is hoped that it will now be apparent to the reader that no one microphone can be obtained capable of fulfilling every recording task, an unfortunate fact that has to be faced. Nevertheless, there are always those who have to obtain the best possible for a minimum of outlay, and here, surely, the crystal microphone is the most attractive proposition. The sensitivity, connected directly to the tape recorder, should be adequate for normal home recording purposes. Live musical recordings would suffer from a lack of overtones, but should otherwise be acceptable. Most crystal units tend to have a peak in their response between 3 and 4 kc/s, and it is therefore inadvisable to try and enhance the high frequency performance by utilising treble "lift" in the amplifier.

It will, perhaps, have been noticed that many of the cheaper commercial tape recorders are supplied with crystal microphones.

To those who are able to afford a greater outlay it must be said that a ribbon microphone is the *second*, not the *first*, that should be bought. For the vast majority of live recordings that the amateur will wish to make, better results can be obtained with a moving

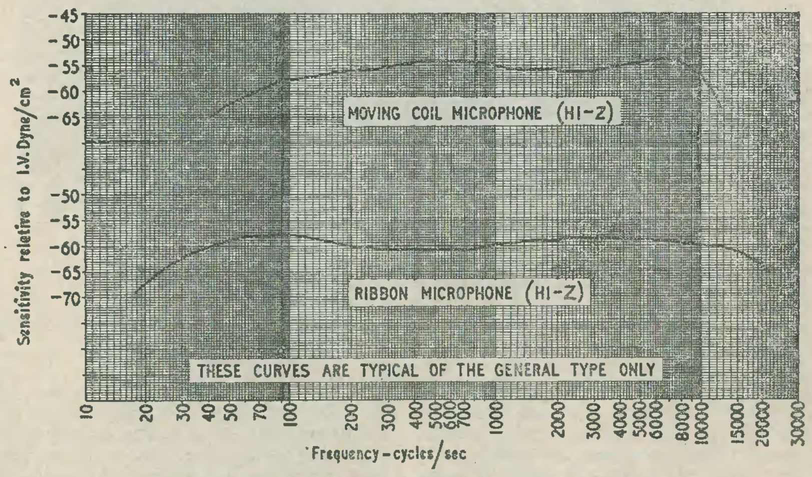


FIG. 2. MICROPHONE FREQUENCY RESPONSE & SENSITIVITY

coil microphone costing 5 gns than with a ribbon that cost ten. Speech forms a high proportion of home recordings, for which a ribbon microphone requires tone correction. In view of what has been said earlier about the better frequency response of the ribbon this may sound surprising, but if such a microphone is used within a couple of feet or so of the speaker, the ribbon tends to "blast," giving an unnatural booming effect. Under such conditions, bass cut should be used, rolling off to some 10 or 15db down at 50 c/s. It is, nevertheless, still better to use the ribbon, without correction, at least 5 or 6 feet from the speaker, with the result that the inherent sensitivity of the ribbon microphone is *effectively* much less than the moving coil.

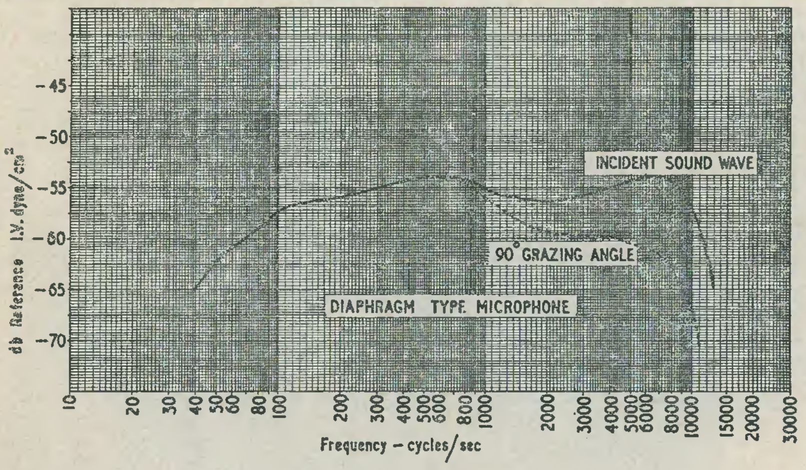


FIG. 3. ANGLE OF SOUND SOURCE vs FREQUENCY RESPONSE

The hi-Z versions, now obtainable, obviously are more convenient for use with an existing tape recorder that has a high impedance input. The recommended load impedance for these types, by the way, is from 470kΩ to 1MΩ. Wherever possible, the writer would recommend the use of low impedance microphones, with a separate matching transformer.

The subject of "Room Acoustics" was mentioned briefly earlier on, and it is felt that a further word here might prove to be of assistance. The best of ribbon microphones, connected to the best of tape recorders, will not necessarily do justice to the living-room piano. In the humble opinion of the writer, this is largely due to "selective" properties of the ear. When listening to the sound "live" we unconsciously reject, to a large extent, the reflected sound coming from walls, windows, furniture, etc., each of which have different properties of absorption for the different frequencies. The microphone, however, cannot do this, and the ultimate replay gives us the total sound from the one loudspeaker whereupon the ear has no chance to exercise its selective powers. The problem can be overcome to a large extent by utilising the directional properties of the microphone, placing the instrument to be recorded in one "lobe" and deadening the zone to the rear of the microphone by, say, draping blankets over a clothes-horse. Care should be taken over which part of the room is on the far side of the source of sound. A large window is bad, a wall-papered wall is better, but the best that can probably be achieved at home is a window over which *heavy* curtains have been drawn. The aim is to confine the sound being picked up by the microphone to direct waves only. Experiment in any given room will also determine an optimum distance and direction of the microphone relative to the piano.

Although moving coil microphones are usually non-directional, they can be obtained with a heart-shaped or "cardioid" response, which would be found to be an advantage, even with speech recordings. Such microphones are virtually "dead" to the rear, and will considerably reduce the background noise of, for instance, other people who may be talking. Due to room reflections, the noise reduction would be far greater when such a microphone was used out-of-doors.

TABLE 1

SUMMARY OF MICROPHONE CHARACTERISTICS

Type of microphone	*Impedance*	*Approximate Sensitivity*	*Frequency response*	*Optimum distance Output voltage speech*	*Remarks*
Crystal	High	−55db	50 c/s–6 kc/s	1–1½ft 10mV	Cheap
Condenser	High	−50db	40 c/s–11 kc/s	1–1½ft 20mV	Needs polarising
Moving coil	25Ω	−88db	70 c/s–6 kc/s 150c/s–10kc/s	1–1½ft 300µV ½–1ft 1mV	Ideal for general purposes betterthan crystal
Moving coil	50kΩ	−55db	as above	10mV or 30mV	
Ribbon	25Ω or 50kΩ	−92or−60db	30 c/s–12 kc/s	6ft 10µV or 300µV	Not so suitable for speech

We have so far spoken of the directional properties of a microphone as an advantage. All diaphragm-type microphones, which excludes ribbons, have a directional property that can be a distinct disadvantage. A microphone, moving coil or crystal, that is omnidirectional at 100 c/s, will have pronounced directional properties at 10 kc/s. The reason is that at the higher frequency the diameter of the diaphragm may be comparable to, or even greater than, the wavelength of the sound wave. When the wave front is incident to the plane of the diaphragm, the successive compressions and rarefactions of the air can be followed. If the wave front is arriving at an oblique angle, however, the result can well be described as "pulling" on one side of the diaphragm, while the other side is being "pushed." The resultant effect on the frequency response of the microphone can be seen in Fig. 4. It must be emphasised that, as with the other illustrations, the information given is the average of a number of examples, and should not be taken as indicative of any particular model.

This directional effect at the higher frequencies should not have too much importance attached to it. It will normally be sufficient to bear the effect in mind when recording a group of people or instruments through the medium of one microphone. The grouping employed should then be such as to allow sound sources that would suffer most from treble attenuation to face the diaphragm directly.

It has been the intention of the writer, in these two articles, to show that the microphone need not be the weakest link in the tape-recording chain. If it is, it is often because it is being asked to perform a task not within its capabilities, or it possibly only seems to be, because the local acoustic conditions are poor. It is here, of course, that the home enthusiast starts off at second best compared with recording and broadcasting studios, but it is surprising how patience and experiment will overcome some of these difficulties.

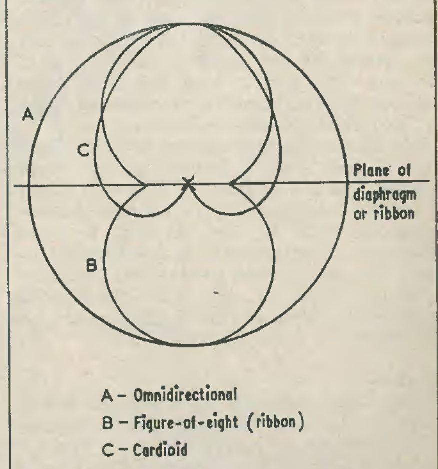


FIG. 4. MICROPHONE POLAR DIAGRAMS

RECEIVERS

THE "PETITE" BATTERY ELIMINATOR UNIT

Described by **JAMES S. KENT**

For those readers who have built the "Petite" portable superhet described in our December issue, or those contemplating doing so in the near future, we now offer a battery eliminator unit capable of being contained within the actual receiver cabinet. The unit, once constructed, is specifically designed to fit within the battery housing clips; thus no external additions are required and nothing extra is visible with the eliminator in operation except the mains lead.

The advantages of such a unit are very obvious, but apart from the financial saving with the continual replacement of batteries, the eliminator unit may be used with other equipment capable of being run from a 90 volts at 15mA and 1.4 volts at 0.125A power source. With the power unit the "Petite" portable receiver may be used as the main domestic receiver or as the kitchen or bedside set, instead of the more usual practice of bringing the receiver into use only when outdoor entertainment is required—in order to "save the batteries"!

The eliminator may also be used by those who already own a similar portable type receiver and are desirous of adding a mains unit to the equipment, or for any small battery apparatus such as, for example, a signal generator. The ultimate saving effected by using these eliminators soon offsets the actual purchase price of the few components required in the circuit, and a glance at Fig. 1 will show that these are few indeed.

Circuit

The circuit consists of a double-wound mains transformer having primary tappings at three ranges of mains voltages. The h.t. supply is rectified by a contact cooled metal rectifier (MR$_1$) in a half-wave circuit, with R$_1$ and C$_1$ as the smoothing components, these delivering a ripple-free h.t. output to the connecting sockets. The l.t. section of the circuit is composed of MR$_2$ as a full-wave rectifier with R$_2$ and C$_2$ and C$_3$ as the smoothing components. MR$_3$ is included into the circuit as a precautionary measure—should the first half of this double rectifier break down, a rectified d.c. voltage will still be delivered to the output and, what is more important, the valves themselves will not "burn out."

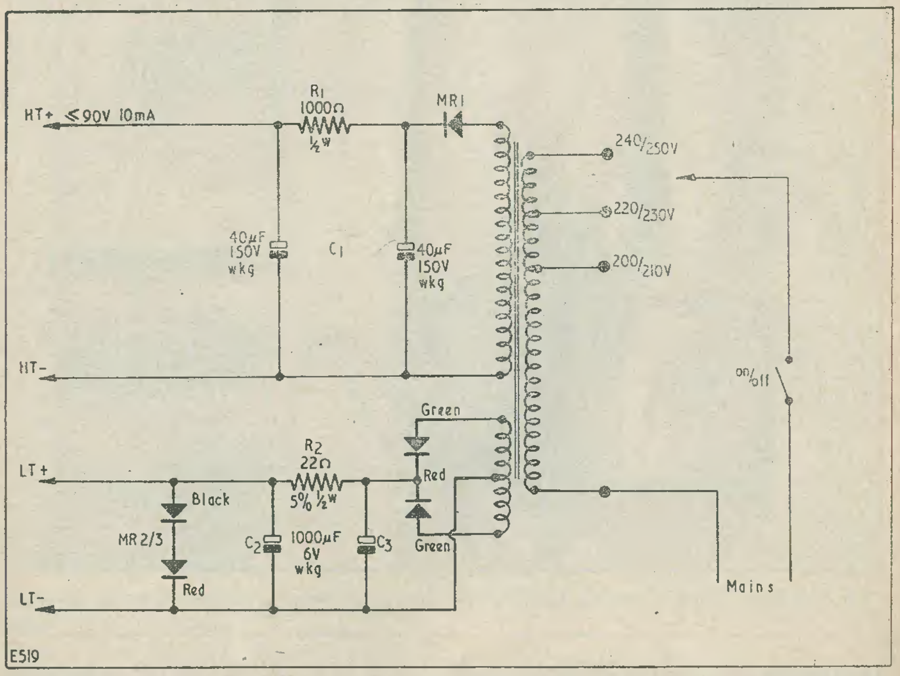
The circuit is a simple and perfectly standard one, the construction of which need not cause even the veriest beginner any misgivings. The small but efficient double-wound mains transformer completely isolates the unit from any direct contact with the a.c. mains. Both the l.t. and the h.t. outputs are completely isolated from the two metal cases, these outputs being terminated in a two- and three-pin socket respectively.

Assembly and Wiring Instructions

A glance at the photographs will show that one of the two metal cases contains both C$_2$ and C$_3$ of the l.t. smoothing section, and the l.t. output sockets. Dealing with this half of the unit first, solder the negative end of one of the condensers to the earthed tag (already fitted to the case). *Note*—This should be that condenser nearest the rubber grommet fitted into the casing wall. Over the positive connection of this condenser fit a short length of p.v.c. sleeving. To the end of this positive connection, solder a length of green p.v.c. covered wire (about 12 inches in length), the other end of which will be soldered at a later stage. This wire should be fed through the rubber grommet and left for the time being. With the second condenser, solder the negative end to earthed tag (again already fitted to the case), and from this junction connect a short length of red p.v.c. wire to the smaller of the two tags of the l.t. output paxolin strip. Dealing with the positive end of the condenser, cover the existing wire with a short length of sleeving and solder to this end a short length of red p.v.c. wire, the other end of which should now be connected to the larger of the tags contained on the l.t. output strip. A further length of red p.v.c. wire, about 12 inches in length, should now be soldered to the positive end of this condenser, this wire being fed through the rubber grommet. Returning now to the first condenser, solder a similar length of grey p.v.c. wire to the negative end and feed this through the rubber grommet. We now have three lengths of wire through the grommet—grey from the negative end of the first condenser (that fitted nearest the grommet); green from the positive end of the same condenser and red from the positive end of the second condenser. Having checked that the foregoing instructions are complete and correctly wired, this unit may now be fitted with the metal lid casing by means of the four self-tapping screws—at the same time ensuring that neither of the positive connections are touching the metal casing.

Dealing now with the main unit, fix into position the mains transformer, the contact-cooled rectifier, the small tag-strip and the h.t. output strip—all as shown in the photograph. In the lid of the unit fit the small metal rectifier MR$_2$/$_3$.

We shall deal with part of the wiring of the mains transformer first, but before so doing a word of warning to those following the photograph connections. The transformer shown in the illustration is that of the prototype; those now supplied are of the same type and dimensions, but the actual connections are reversed, i.e., the 90V h.t. output side is opposite to that shown. In the following written instructions, the wiring directions are given for the new transformer as now supplied to the reader—and *not that shown in the photograph.*



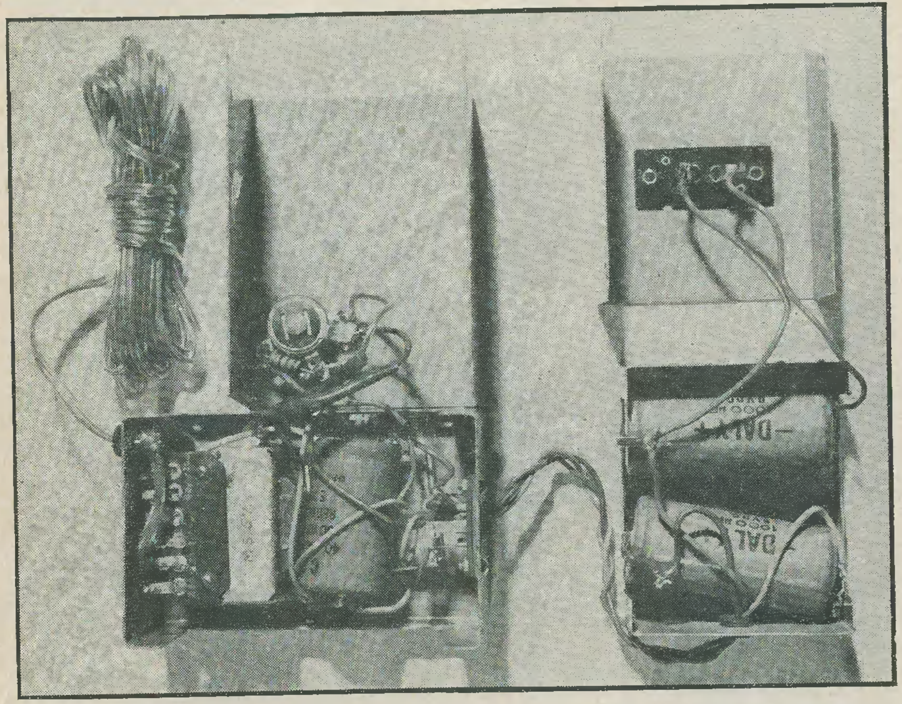
Circuit of the "Petite" Battery Eliminator

Parts List

2 metal boxes, sprayed (Premier Radio)
3 2-way tag panels
1 mains transformer (Premier Radio)
1 h.t. rectifier, 60mA type (Westinghouse)
1 l.t. rectifier-stabiliser (S.T.C.)
1 40–40µF 150V wkg. electrolytic (C$_1$)
2 1,000µF 6V wkg. electrolytic (C$_2$, C$_3$)
1 22Ω ½W 5% (R$_2$)
1 1kΩ ½W 20% (R$_1$)
1 2-way non-reversible plug socket
1 3-way non-reversible plug socket
Mains lead, self-tapping and BA screws, grommets, nuts, wire, etc.

Feed one end of the mains input wiring through the rubber grommet and, about two inches from this end, tie a small knot in the wire. This will obviate undue strain on this wire and the soldered connections. Looking at the transformer, with the tags nearest to the constructor, bare both the mains input wires and solder the end of one to the second tag from the left and the other bared end to that tag being the fourth from the left. Bare both of the mains wires at the far ends and connect these to a mains plug. To the extreme right-hand tag of the mains transformer solder a short length of p.v.c. wire, the other end of which should now be connected to the negative connection of the contact-cooled metal rectifier MR_1, this being the largest of the rectifiers. To that transformer tag being the second from the right, solder a short length of p.v.c. wire, the other end of which is connected to the negative—or plain metal—end of the condenser C_1. From the same end, solder a short length of bare wire to the free tag of the small tag-strip (i.e. that tag *not* earthed). To this latter connection, solder a length of p.v.c. wire the other end of which should now be soldered to the right-hand tag of the h.t. output strip—looking at the strip from the rear.

To the earthed tag of the small strip mounted on the "floor" of the unit, solder a length of p.v.c. wire, the other end being soldered to the lower red tag of the small rectifier ($MR_{2/3}$) mounted in the lid (looking at the rectifier from directly above and looking down into the lid casing). The other end of the grey wire should now be connected to this same earthed tag—this grey wire being that coming from the negative end of the condenser mounted in the other case. It should, of course, be first fed through the rubber grommet fitted to the main unit. Across the white and red tags of the condenser, C_1, solder the resistor R_1, one end of the resistor to each tag. To the red tag of the same condenser solder a short length of p.v.c. wire, the other end of which should now be soldered to the left-hand tag of the h.t. output strip mounted on the casing wall of the main unit (looking at the strip from the rear). To the same red tag, solder a short length of bare wire, the other end of which should be connected to the positive (+) connection of the metal rectifier MR_1.



The two units which comprise the "Petite" Battery Eliminator shown with lids removed

Three wires are now left coming from underneath the mains transformer; of these, two are orange and one is yellow. Bare the ends of these three wires and solder the yellow wire to the lower red tag of the small metal rectifier $MR_{2/3}$, looking at the rectifier from above. To the end of one of the red wires (it does not matter which one) solder a short length of p.v.c. wire and cover the soldered connection with a length of sleeving. Solder the free end of this now lengthened wire to the lower green tag of the same rectifier. Deal similarly with the remaining red wire and solder the free end to the upper green tag of the rectifier. To the black tag of this rectifier solder one end of R_2, the other end of which should be connected to the upper red tag of the same rectifier. To the black tag of the rectifier, solder the free end of the red wire coming from the positive connection of C_2 (contained within the other casing). To the upper red contact of the rectifier solder the free end of the green wire coming from the positive end of C_1 in the other casing. These latter wires must first, of course, be fed through the rubber grommet on the main unit wall.

This completes both the assembly and wiring instructions for the battery eliminator unit. Having first checked the wiring, both with the circuit of Fig. 1 and the foregoing instructions, the mains plug should now be inserted into the a.c. supply and the output voltages tested with a meter set to the appropriate ranges.

Having completed the tests, the remaining lid should now be secured into position by means of the self-tapping screws. In the case of those readers not possessing a meter, the unit may be tried out on a receiver with only one valve inserted, this being seen to glow with the flow of the l.t. current.

The unit may now be fitted into the "Petite," or similar type equipment and secured by means of the metal fastening strips, the appropriate power input plugs of the receiver being inserted into the eliminator output sockets.

Can Anyone Help

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

To avoid any unnecessary duplication, readers are advised to write before sending any literature.

J. WILLIAMS, The Unicorn Inn, Brettle Lane, Stourbridge, Worcs., wishes to obtain information on the No. 19 Set, Mk. 2, in particular the 6-pin and 12-pin panel socket connections.

* * *

C. H. O'REILLY, 857 Piercetown, Newbridge, Co. Kildare, Eire, says he is just a beginner in radio and would therefore be glad of any magazines or books on the subject. Postage will be refunded.

* * *

R. S. MORROW, 54 Cyprus Road, Mapperley Park, Nottingham, is willing to pay for any information on, and would be glad to receive the circuit of, the switching of the RA.10 series receiver.

* * *

P. POYNTER, 79 Wrythe Lane, Carshalton, Surrey, wishes to borrow or purchase the circuit of the Homelab Signal Generator type 10, using two E1148 valves.

* * *

S. O. OSHOKOYA, 65 Uplands Road, London, N.8, asks if any reader can advise him of the name and address of any maker of a car burglar alarm of any kind. He would also like to know of any firm who can supply in kit form all the circuits described in *Electronic Gadgets* published by Bradley. All letters will be promptly acknowledged.

S. A. JORDAN, 58 Bushfield Crescent, Edgware, Middlesex, would like to borrow, or preferably buy, a service manual for the Ekco model TC138/T141 televisor.

* * *

E. MATTHEWS, 63 The Oval, Newall, Otley, Yorks., is badly in need of the data, circuit, etc., for a Durance a.c. radio gramophone of about 1935, and will be glad to hire or pay for any information.

* * *

JACQUES HOEBEN, 107 rue des Trois Tilleuls, Boitsfort, Belgium, wishes to obtain, on sale or loan, the manual or circuits of the TCS.15 Receiver and the BC.973B Direction Finder.

* * *

C. BLOOR, 30 Deyne Avenue, Manchester 14, wishes to buy or borrow for payment the manuals or data on the ART-B Transmitter, TCS Receiver and CG.46116 Receiver.

* * *

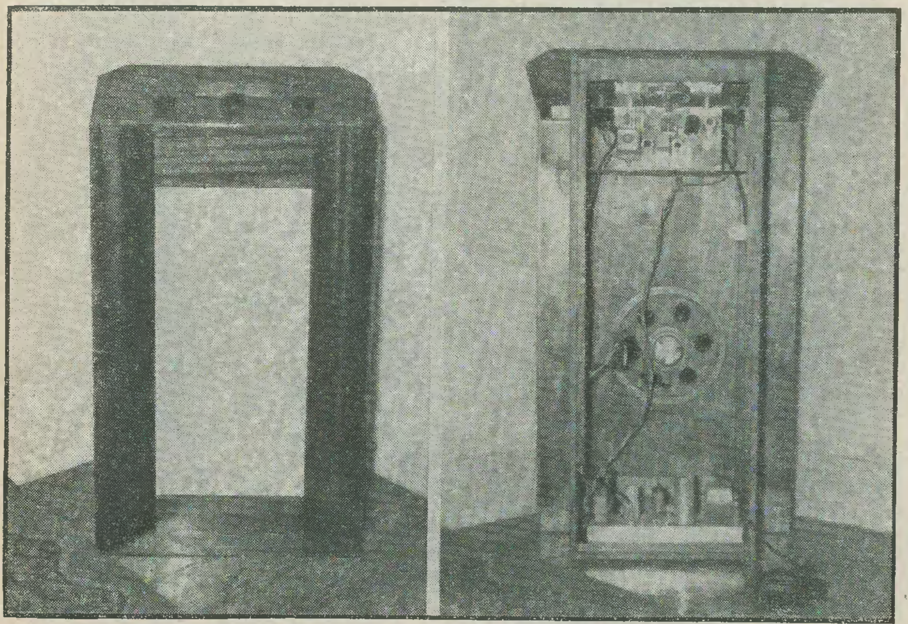
J. C. CODLING, Lingwood, St. James's Road, Dudley, Worcs., would like to purchase or borrow the manual, circuit and any data on the Monitor type 28, ref. 101/500.

An Easy-To-Make Cabinet

by **F. TIDMAN**

Having made an FM tuner and a combined power-pack amplifier, there arose the question of obtaining a suitable cabinet in which to house them. Those available commercially appear to be either a radio-gram cabinet or table model, neither of which was suitable in this instance.

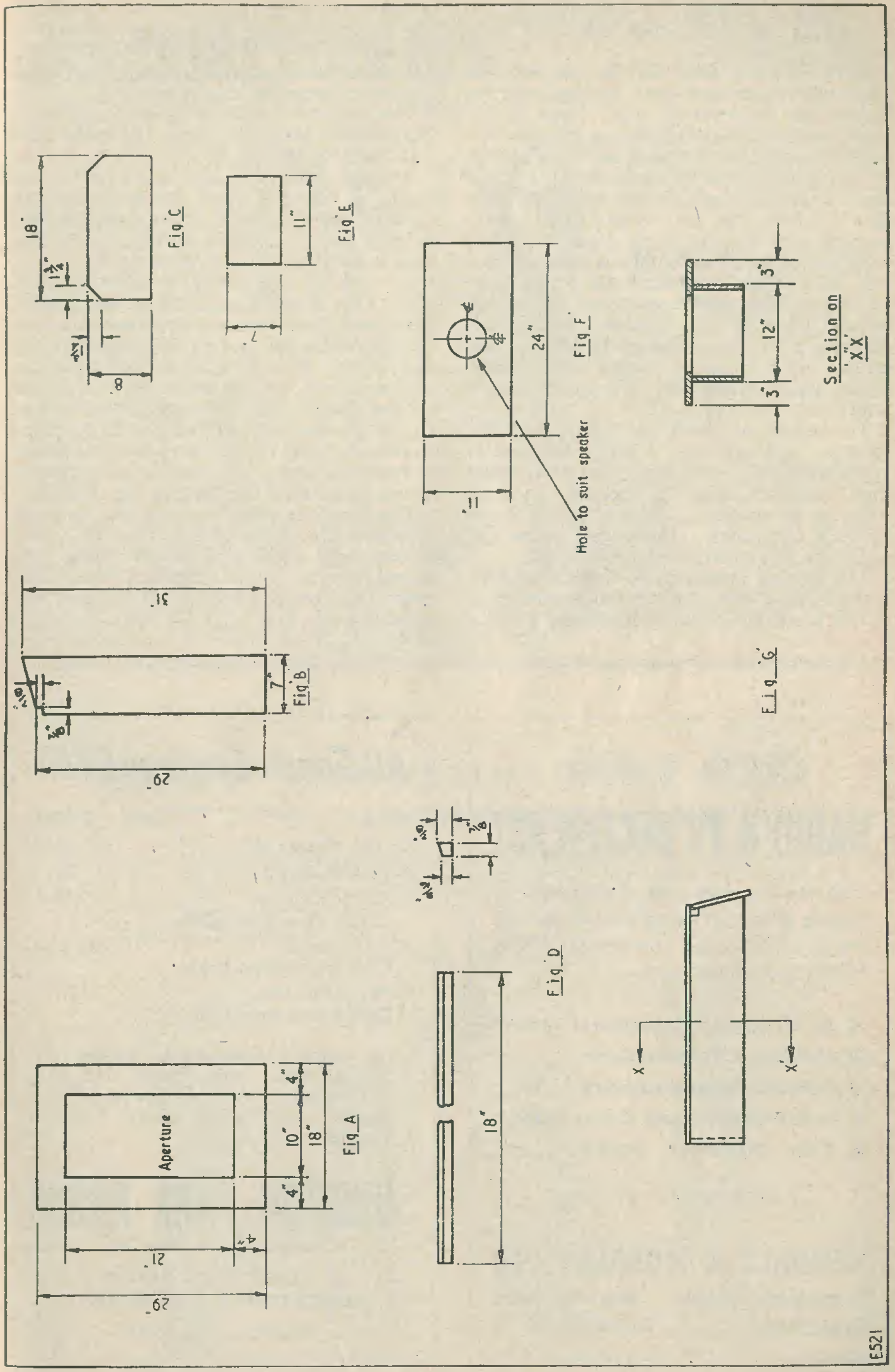
It was, therefore, decided to make something more suitable, and this design was the result. A floor-standing design was desirable so as to provide a reasonable area of speaker baffle. That it should be easy to construct and not too expensive were equally desirable design factors; additionally, very little floor space is occupied. Whilst no attempt has been made to provide a speaker enclosure in the Hi-Fi sense, the reproduction is very pleasing. Plywood of ½in thickness will be suitable, except for the top panel, which should be ¼in. The front panel and top will need to be veneered for the sake of appearance. This can be achieved by using plywood already veneered in which case extra care must be taken during cutting, etc., to avoid damage to the edges. However, it is not very difficult to apply the veneer after construction with the aid of a glue-pot and the domestic flat-iron (preferably an old one).



Front and rear views of this attractive cabinet

As will be seen from sketches A-G, everything is quite straightforward, with the possible exception of "D." When cutting the two sides "B" ensure that they are a pair, i.e. face-sides outwards.

Cut the aperture in the front panel "A," and smooth the edges. Cut suitable aperture and holes in top panel "C."



The actual assembly is a matter for 1in panel pins and glue, which will result in a perfectly strong job.

Start by fixing fillet "D" to the back of "A," and downwards from the top edge by exactly the thickness of "C." Next fix the sides, ensuring that "C" fits snugly to "A" and "D" and is supported at the correct angle by the sides. Now fit the bottom "E" and then a stretcher across the top rear of the sides $\frac{3}{16}$in in from the rear edge. This piece, together with further strips down the sides, will support the hardboard back. Now fit the top "C." This completes the actual construction. The cabinet can now be cleaned up and papered dead smooth. The actual finishing is a matter of taste; the original was stained with "Colron" wood dye, walnut shade, and polished with "Furniglas" french polish.

The edges of the front panel and the speaker aperture are filled with several applications of wood filler, and then given three or four coats of lacquer, such as Valspar, in cream or brown. Rub down between each coat. The edges of the top panel can be similarly treated.

The speaker aperture can now be covered with a suitable fabric, and the baffle screwed in.

The hardboard back should have a series of large holes drilled in it to provide ventilation and prevent boom. These, too, should be covered with a dust-excluding fabric.

The actual installation of tuner and amplifier will depend on the types used.

The writer's f.m. tuner is as described in *The Radio Constructor*, Sept. 1954, and uses a Jackson SL.16 dial.

A rectangular opening 1½in × ⅜in in the centre of the dial plate ½in from the top accommodates a DM70 tuning indicator held in position by a simple springy brass clip. This is wired as in the "Argonaut."

A strip of 16 s.w.g. aluminium alloy 10in × 1½in is bolted on to the front apron of the chassis, and carries a volume control on the right-hand end and a rotary mains switch on the left. This gives a symmetrical layout and separates the on/off switch from the volume control, thus preventing that frequent source of noise, an excessively used potentiometer. Another suitable strip of metal bolted to the back apron will provide a convenient means of securing the tuner in the cabinet.

The amplifier, which is built on the same chassis as the power-pack, is the Micro-amp circuit using 6BR7 and 6BW6 valves. As record-playing is not required, the "top" control was omitted and the n.f.b. preset to a suitable level.

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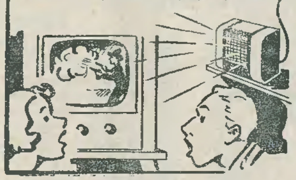

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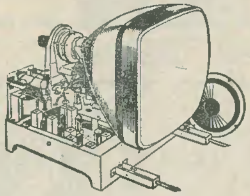

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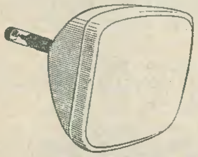

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6B8	3/9	8D3	7/9	ECH42	8/9	EL91	3/9
6F12	7/9	12AU7	5/9	EF39	6/9	PEN45	6/9
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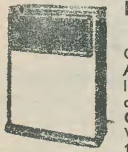

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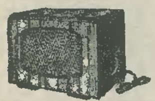

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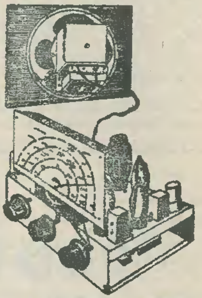

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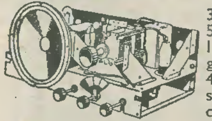

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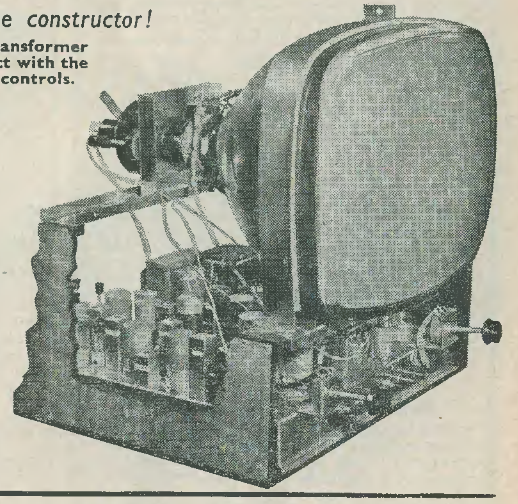

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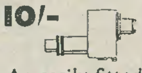

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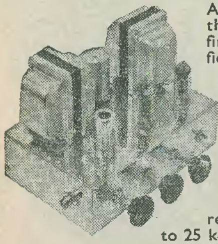

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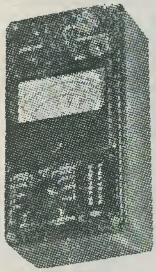

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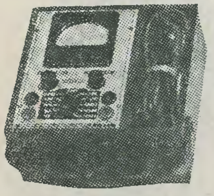

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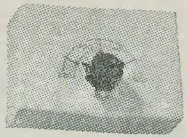

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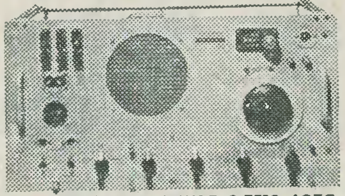

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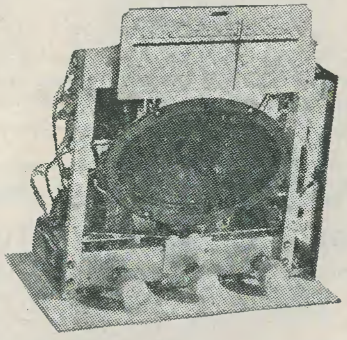

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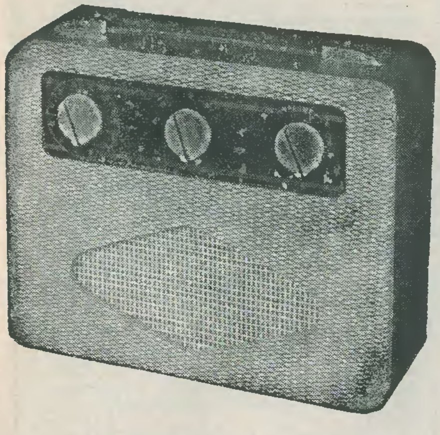

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Call and hear demonstration model

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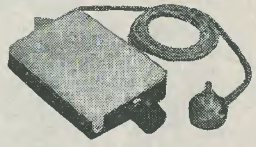

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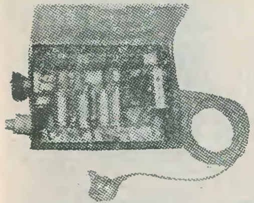

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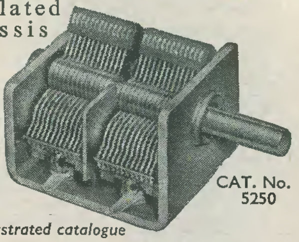

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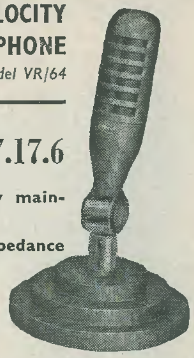

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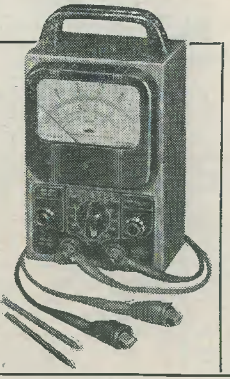

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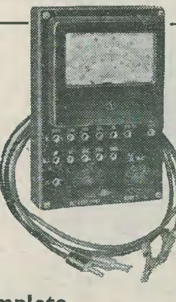

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continued on page 527

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continued from page 527

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SERVICE SHEETS for sale and hire. Radio, t.v., electrical and ex-Government equipment. Sultan Radio (RC), 11 Old Bond Street, London, W.1.

HUNDREDS OF INTERESTING ITEMS, ex-W.D. Free list. Rogers, 31/33 Nelson Street, Southport

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A.M.I.P.R.E. For details of suitable study courses (only a limited number of students accepted), send for free Syllabus of Instructional Text. I.P.R.E. Conditions of Membership booklet 1/–. *The Practical Radio Engineer* journal, sample copy 2/3. 6,000 Alignment Peaks for Superhets 6/–. All post free from Secretary, I.P.R.E., 20 Fairfield Road, London, N.8.

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LEARN as you do it—we provide practical equipment combined with instructions in Radio, Television, Electricity, Mechanics, Chemistry, Photography, etc. Write for full details to E.M.I. Institutes, Dept. RC47, London, W.4.

continued on page 528

RADIOSETTE

(Featured in June Issue)

The ideal low cost transistor pocket radio for the beginner. The circuit utilises the new R.C.S. VARILOOP-STICK transistor coil. A specially designed miniature .0004 tuning condenser permits the set to be in a case which fits the palm of your hand.

Can be built in 30 minutes **30/-**

All components are sold separately, full construction data including plan of parts, 2/–

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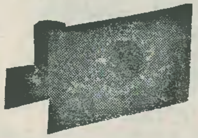

This 1 valve S.W. receiver can be built for 30/– from our list of components, which can be purchased separately. It includes valve and 1 coil covering 20-40 metres. Provision is made to increase to 2 or 3 valves if required, and all components are colour-coded so that the beginner can build this set quite easily. *Send 2/– for specification, wiring diagram, layout and price list.*

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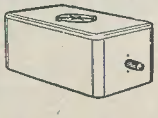
"RECO" ALL-WAVE 1 TRANSISTOR KIT



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Parts Price List, Wiring Diagram, 1/– P.O.

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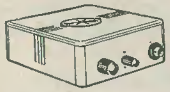

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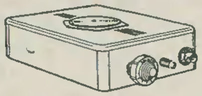

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Parts Price List, Wiring Diagram, 1/– P.O.

All parts sold separately

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(Dept. RC) 27 HARPER STREET BEDFORD

SMALL ADVERTISEMENTS

continued from page 527

TRADE—*continued*

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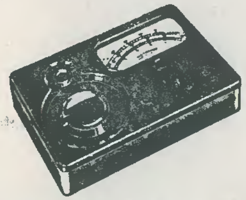

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