APRIL 1961

The RADIO Constructor

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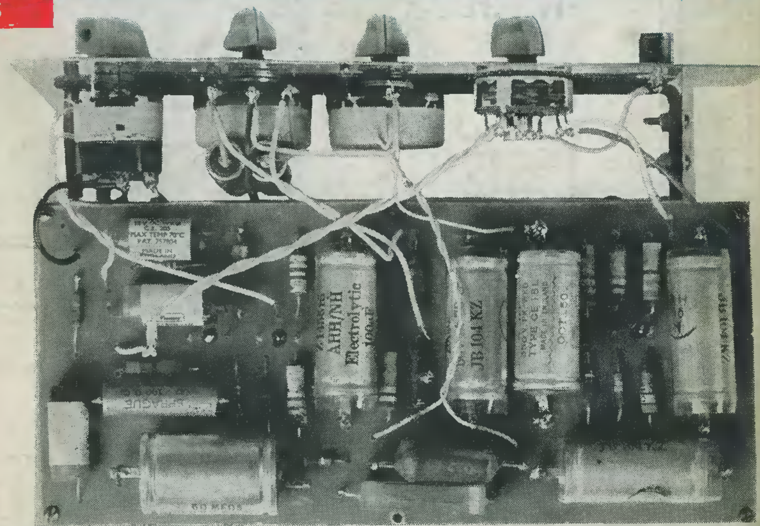

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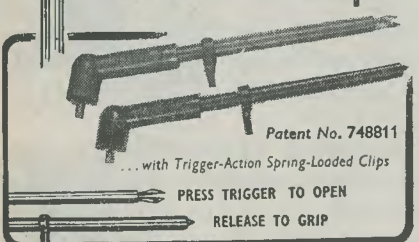

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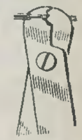

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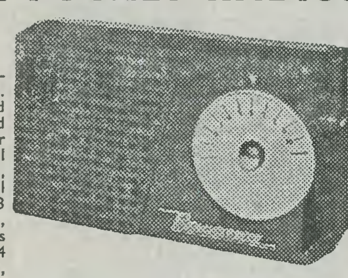

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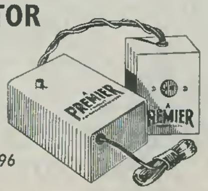

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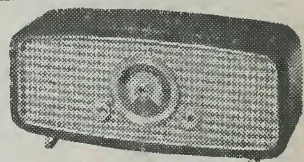

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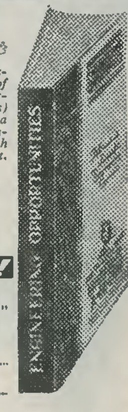

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Suggested Circuits

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

No. 125. A Transistorised Capacity Meter

This month's suggested circuit is for a simple and relatively inexpensive capacity meter which employs two transistors and which can be powered by a 9 volt battery having a tap at 4.5 volts. The capacity meter has a useful overall range of 5 to 5000pF. It may be built up into a compact and self contained unit, a factor which makes it attractive for outside servicing work in addition to conventional applications in the workshop or laboratory. The capacity of the condenser under test is found by adjusting a calibrated two-gang tuning condenser with both sections paralleled, correct capacity being indicated by a sharp "dip" in the reading of a 0–1mA meter.

Making up the capacity meter should not raise many difficulties, especially for the more experienced constructor; but it must be pointed out that some component values are critical and may need adjustment from those shown in the diagram. Also, one of the coils required is not directly available through home constructor channels, since it consists of a conventional coil modified. A Medium wave broadcast receiver is needed during construction to carry out simple checks on the operation of part of the circuit.

The Circuit

In the circuit, which accompanies this article, the condenser whose capacity is to be measured is connected to the two test terminals at the left hand side of the diagram. When S_1 is set to Range 1 the test condenser is connected directly across coil L_1. L_1 is the tuned winding in the oscillator circuit around TR_1, its coupling coil L_2 connecting to the base of this transistor. C_4 provides feedback from the collector of TR_1. The frequency of oscillation is governed by the capacity of the test condenser, and component values in the circuit are such that reliable oscillations are obtained for a test capacity range, directly across L_1, from zero to 900pF. When S_1 is set to Range 2 the test condenser is applied to L_1 via the 1000pF condenser C_1, this enabling the range to extend beyond 900pF to some 5000pF. Condenser C_2, connected permanently across L_1, stabilises the oscillator circuit for test condensers having very low capacities. L_1L_2 is a conventional Medium wave r.f. coupling coil.

The oscillatory voltage appearing across L_1 is applied, via C_3 and the tuned circuit C_8C_9 and L_3, to the OA79 shunt detector. The OA79 rectifies, causing a negative voltage to appear on its upper terminal whose magnitude varies with the resonant frequency of the tuned circuit C_8C_9 and L_3. When the tuned circuit is resonant at the same frequency as the oscillator it offers maximum impedance, and the negative voltage on the upper terminal of the OA79 is at a minimum.

The upper terminal of the diode connects, via R_6, to the base of transistor TR_2. A 0–1mA meter, together with variable resistor R_8 and current limiting resistor R_7, is connected in the collector circuit of this transistor. TR_2 functions as an amplifier, and the current flowing through the meter decreases as the negative voltage on the upper terminal of the OA79 decreases.

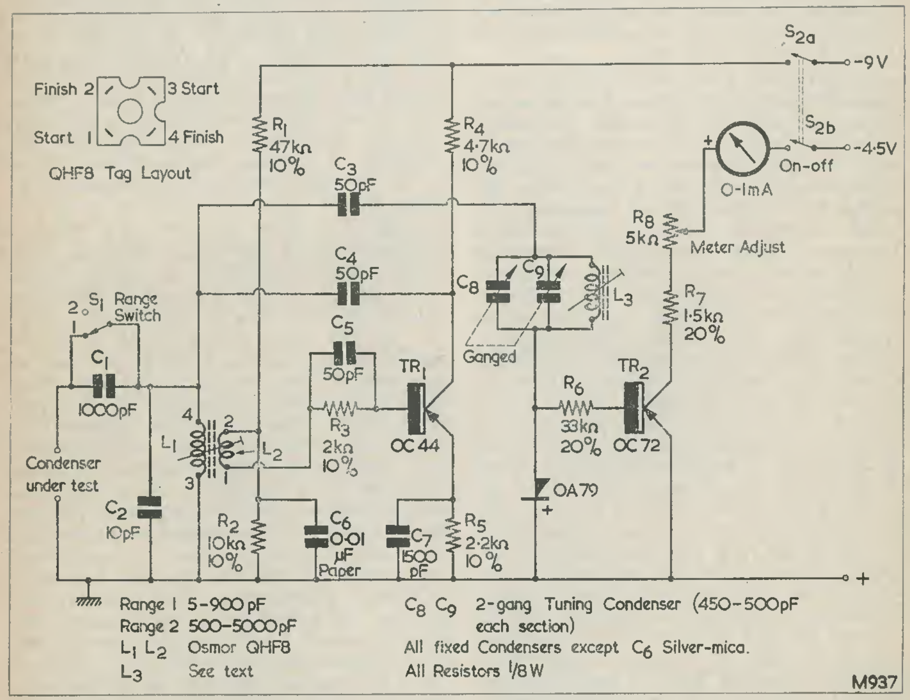
The overall operation of the circuit may be summed up in the following manner. The condenser under test is connected to the test terminals, causing TR_1 to oscillate at a frequency which corresponds to the test capacity. Condenser C_8C_9 is swung for minimum reading in the 0–1mA meter, this corresponding to minimum voltage on the upper terminal of the OA79 and to resonance in C_8C_9 and L_3 at oscillator frequency. The value of the test condenser is then read from a scale fitted to C_8C_9.

Points of Design

There are several points in the design of the capacity meter which need consideration.

To begin with, it is a requirement of the oscillator circuit around TR_1 that reliable oscillations at fairly constant amplitude be generated when L_1 is tuned by a parallel capacity ranging from slightly greater than 10pF (C_2 plus circuit strays) to 900pF. This is a much wider range of tuning capacity than is given in normal Medium wave oscillator circuits and it was found, with the prototype capacity meter, that the values of some components around TR_1 tended to be critical in consequence. Condenser C_5 and resistor R_3 are inserted in the base circuit of TR_1 to assist in obtaining reliable oscillations over the wide tuning range. The presence of R_3 in series with the base limits base r.f. current and helps to keep oscillator amplitude reasonably level, particularly over the higher frequency end of the band of frequencies covered. Condenser C_5, across R_3, boosts oscillator amplitude at the low frequency end of the band. Emitter resistor R_5 is a normal stabilising component, but its parallel condenser C_7 has a value which is low enough to permit a small level of negative feedback. In the prototype C_7 was fairly critical (within plus or minus some 300pF) and its value may require adjustment in units built in conformity to the circuit. The question of component value adjustment is discussed later when constructional details are given. It should be pointed out that the values shown in the circuit were arrived at using an Osmor QHF8 coil in the L_1L_2 position. Other coils will almost certainly require different component values around the transistor.

When, in the prototype, component values had been finalised at those shown in the diagram, oscillator performance was checked by deleting C_2 and connecting a two-gang condenser, with both sections (each 500pF) paralleled, across L_1. The oscillatory voltage across L_1 was measured. Variations in oscillator voltage as the condenser was swung were smooth, and oscillator voltage was at no time less than 50% of maximum value. (The latter occurring around 300pF tuning capacity). It was considered that these results were adequate



for present purposes.

It was initially intended that the tuned circuit C_8C_9 and L_3 would be coupled to L_1 such that it absorbed energy when it was at the resonant frequency of the latter. In practice, however, this scheme proved unsuccessful owing to the difficulty of obtaining a satisfactory fixed coupling between the two tuned circuits which could cater for the wide range of frequencies covered. The alternative device of connecting C_8C_9 and L_3 in series with the r.f. feed to the crystal diode was then tried out, and was found to be extremely successful. With the prototype, the dip achieved in the milliameter for all values of test capacity checked was always less than 20% of full scale deflection, some values of test capacity (around 100pF) causing dips down to 10% of full scale deflection.

In a capacity meter of this nature it is possible to have the test condenser connected across L_1 and the calibrated condenser, C_8C_9, across L_3 (as is done here), or to have the test condenser across L_3 and the calibrated condenser across L_1. Since the testing process consists of adjusting two tuned circuits to resonate at the same frequency, either method of connection would enable the calibrated condenser to indicate the value of the test condenser. Connecting the calibrated condenser across L_1 has the disadvantage that oscillator amplitude (within the typical limits mentioned above) will vary as the condenser is swung, and dips in indicating meter current would not be so obviously discernible as they would be if meter current were constant on either side of the resonant point. When the test condenser is connected across L_1 oscillator amplitude becomes fixed at the level corresponding to the resultant oscillator frequency, and the dip then becomes obviously apparent. To take up discrepancies for differing oscillator amplitudes, resistor R_8 (which is a panel component) may be adjusted for full scale deflection on either side of the dip. In practice it was found with the prototype that for test capacities across L_1 above 500pF or so, slight changes in meter reading occurred as C_8C_9 was adjusted. However, the discrepancies were such that meter current changed smoothly as the calibrating condenser was swung, and they did not detract from the conspicuousness of the dip.

Connecting the calibrating condenser across L_3 has the disadvantage that the condenser frame must be isolated from chassis in the capacity meter. On the other hand, one of the test terminals connected to L_1 assumes chassis potential, with the result that condensers in equipment being serviced may be measured *in situ*.

It is desirable to have an inductance in L_3 which causes the vanes of C_8C_9 to be completely, or almost completely, disengaged for resonance when no condenser is connected across the test terminals. This is because the rate of change of capacity with spindle rotation in C_8C_9 is at its lowest at the minimum capacity end, and the condenser has to be given the greatest amount of rotation to offer resonance with low value test condensers. The low capacity end of the scale for C_8C_9 suffers, in consequence, the least amount of cramping. In practice, it is desirable to give L_3 an inductance which is such that a dip for zero test capacity is *just* discernible as the condenser is adjusted about its minimum capacity position, since this allows a quick check of meter zero calibration to be made from the front panel. The resultant capacity in C_8C_9 which corresponds to zero capacity would then be approximately that in which the moving vanes just commence to mesh with the fixed vanes. When the prototype was set up in this manner if was found to be capable of being calibrated down to some 5pF.

Since the tuned circuit C_8C_9 and L_3 has considerably less parallel stray capacity than is present across L_1, the desired inductance in L_3 to meet the requirements just quoted is considerably higher than that in L_1. The writer cannot specify a readily available coil for the L_3 position, but he can state that it should not prove too difficult to modify a conventional Medium wave coil. The procedure adopted in checking the prototype may prove helpful to constructors, the processes involved being relatively simple to carry out. The circuit was first of all checked by using a conventional air-cored single-winding Medium wave coil in the L_3 position. The particular coil employed was wound with Litz wire in a single pie on a former having a diameter of ½in. The inductance of this coil was then increased by the simple expedient of scramble-winding a further 35 turns of 30 s.w.g. rayon covered enamelled wire over the top of the existing winding, and by inserting an adjustable iron dust core. Modified in this manner the coil gave the desired inductance and was capable of being finally adjusted with the iron dust core. Despite the fact that the additional turns were of single strand wire, instead of Litz, the Q of the modified coil was sufficiently high to allow the dip figures at resonance mentioned above to be achieved. The added core, incidentally, offered a convenient "zero-set" adjustment fort he meter as a whole.

Little else in the circuit requires comment except, perhaps, the components specified for the crystal diode and TR_2 positions. An OA79 was employed in the prototype, but the choice of diode here should not be very important. Most alternative types should give equivalent results. An OC72 was fitted in the TR_2 position in the prototype, but the function it carries out is not of a critical nature. Most general purpose a.f. transistors should cope in place of the OC72, although they may require different values in R_6.

Constructional Points

The layout of the capacity meter is not critical provided that no inductive coupling exists between L_1L_2 and L_3. These two coils should be mounted some distance from each other with their axes at right angles. A good plan consists of positioning C_8C_9 between the two coils, whereupon its bulk provides a measure of isolation between them.

C_8C_9 should, of course, be insulated from chassis. The capacity to chassis of all components in either tuned circuit should be kept as low as possible. Of the two test terminals, that connected to C_1 should be mounted on an insulated panel with at least ⅜in clearance from chassis all round. Variable resistor R_8 is mounted on the front panel.

Suitable batteries would consist of a 9-volt grid bias battery or two 4.5 volt flash-lamp batteries in series. However, current requirements are so small that much smaller batteries may be used, if desired. If, due to the use of miniature batteries, a high internal battery impedance is expected, a 0.01μF condenser should be connected between the 9 volt negative h.t. rail and chassis.

After a suitable layout has been determined, the capacity meter should be assembled with C_2, L_3 and C_8C_9 omitted. Before these components are fitted, the oscillator circuit has to be checked; and this is done in the following manner.

Connect the right-hand plate of C_3 to the upper terminal of the OA79. The 0–1mA meter will now monitor oscillation amplitude directly. Temporarily connect C_8C_9, with both sections paralleled, across the test terminals, and set S_1 to Range 1. Adjust the dust core in L_1L_2 such that it offers maximum coupling between the tuned and coupling windings. Switch on the unit and swing C_8C_9 across its entire range. There should be a reading in the meter for all settings of C_8C_9 and this should not drop to less than 40% of the maximum reading obtained. (The figure of 40%, 10% less than that given by the prototype, should be adequate in practice). If the presence of oscillations is doubted, a positive indication is given by the fact that the meter reading will drop to a low level when tags 3 and 4 of L_1L_2 are short-circuited. Couple the aerial of a broadcast receiver switched to Medium waves to the oscillator tuned circuit by holding a wire from the aerial socket close to L_1L_2. It should be possible to obtain clean heterodynes with stations spaced around the Medium wave band as C_8C_9 is adjusted. If a loud hiss from the receiver is evident as the resonant frequency of the oscillator approaches that of the station being received the oscillator is squegging, and this is an undesirable condition. The whole purpose of the check with the receiver is to ensure that squegging does not occur.

If the oscillator fails to meet the requirements just given, C_7, C_5 or R_3 may need adjustment. Too high a value in C_7 causes squegging whilst too low a value causes amplitude at the low frequency end of the range to drop. C_5 boosts response at the low frequency end of the range and may be increased or decreased accordingly. When R_3 has too low a value there may be abrupt, instead of smooth, changes in oscillator amplitude as C_8C_9 is swung.

When the oscillator has been checked and is giving satisfactory results, C_8C_9 should be connected into the proper position in circuit, and C_2 should be fitted. For the time being, a conventional Medium wave tuned winding may be fitted in the L_3 position. The complete circuit may then be quickly checked for varying test capacities from 5 to some 900pF on Range 1, and for the appropriate values on Range 2. At each test capacity a pronounced dip should be given in the meter (after R_8 has been adjusted) when C_8C_9 is at the appropriate resonant setting. The coil in the L_3 position may then be modified, or another fitted, following the suggestions given earlier.

The final process consists of calibrating C_8C_9 against known values of capacity, the calibration including the overlap between Ranges 1 and 2. Range 2 will occupy only part of the 180° range of rotation in C_8C_9. There is no point in calibrating Range 1 above 900pF or Range 2 below 500pF.

Current Consumption

The current consumption from the 9 volt supply, as measured on the prototype, lay between 0.4 and 0.8mA, according to the value of the test condenser. The current drawn from the 4.5 volt supply is, of course, that indicated by the 0–1mA meter.

IN YOUR WORKSHOP

This month Smithy the Serviceman, and his able assistant Dick, encounter some of the problems which beset many of us at this time of year.

Like all great men, Smithy the Serviceman had his little eccentricities. One of these exhibited itself in an almost fanatical desire to maintain order and uniformity in the permanent mains wiring which was installed in the Workshop. Under Smithy's eagle eye all additions and alterations to this wiring had been made to conform to a standard which he himself laid down; and he obtained great satisfaction whenever he looked at the neatly cleated wires which travelled exactly parallel to each other around the walls. In Smithy's scheme of things a permanently installed mains cable could only be horizontal or vertical, and the transition from one state to the other must be contained within a right angle having a corner as sharp as the insulation of the wire would allow.

All the mains wiring in the Workshop originated from a large wooden block near the door which was fitted with two rows of switches. At the end of each day Smithy would stand at this board and snap off each in turn. It gave him a feeling, he once confided to his assistant Dick, rather as though he were a captain on his bridge. When Dick passed this information on to his uncle (who was the Steward at Smithy's club) the latter remarked that it reminded him of the landlord of a pub at closing time.

Switchboard Modification

Arriving at the Workshop before Smithy, it was to this switchboard that Dick turned one morning. Moving feverishly, he extracted two switches from his mackintosh pocket, and quickly screwed them to the board at the left hand end of each row of switches. He had just completed this job when he heard Smithy's approach. With a sigh of satisfaction he left the switchboard and proceeded to leisurely remove his mackintosh.

"Morning, Smithy."

"Good morning, Dick," replied the Serviceman heartily. "You're bright and early this morning! Well, let's have a bit of light on the scene."

Subconsciously following his usual practice of counting over the switches, Smithy depressed two of them. The dial lamp of a receiver on Dick's bench at once lit up.

"Well, that's queer," commented the Serviceman.

The puzzled frown on Smithy's face grew even deeper as a television receiver on his own bench commenced to give a 10 kc/s line whistle. Perplexedly, Smithy watched a blank raster form on its screen.

Smithy tried several other switches, and his expression changed to complete bewilderment as he found that each switch controlled a service different to that he had expected.

"This is quite fantastic," he muttered. "The wiring behind the switchboard just *couldn't* have changed over like this on its own."

Suddenly a suspicious gleam came into his eye, and he slowly counted the switches in each row. He then turned round to his assistant who was, by now, almost doubled up. Speechless, Dick pointed at the calendar on the wall, and a light of understanding dawned in Smithy's face.

"I should have known," he commented bitterly, "it's April the First!"

Bottom-End Coupling

Some ten minutes later the Workshop had fallen into its normal busy routine, with both Smithy and Dick bent over their benches. The two offending switches had now been removed, and the only evidence of the preceding scene was given by an occasional retrospective chuckle from Dick, and a revengeful frown on Smithy's face. Dick was engaged in the repair of an a.m. Medium and Long wave sound receiver and, as he became more and more engrossed in his work, his chuckles gradually ceased.

"Smithy," he called out eventually. "Is it possible to have shorted turns in a coil wound with litz wire?"

"It's not impossible," commented Smithy over his shoulder, "but it doesn't happen very often. Hardly ever, in fact, if the litz wire is rayon covered."

"Then I give up," pronounced Dick. "I've tried everything in his set, and I still can't get at the fault."

Smithy put his test prods down on the bench, and walked over to look at Dick's receiver.

"What exactly is the trouble?"

"It's the aerial input circuit," replied Dick. "The set is a simple Medium and Long wave receiver and the stages are all O.K. from the frequency changer anode onwards. Also, the oscillator's working correctly. But when I try to trim the aerial tuned circuits I can't get any sense at all! Here's the circuit in the service sheet. (Fig. 1.) I've checked the Medium and Long wave coils for resistance, and the Medium wave coil gives about an ohm or so and the Long wave coil about six ohms. Which shows there are at least no open circuits in the coils, but which doesn't confirm whether or not they have shorts between adjacent turns."

"Do you get the same trouble on both Medium and Long waves?"

"Yes. Neither aerial coil will trim."

"Then", remarked Smithy, "the fault lies more probably in a common component than in the coils. They would hardly both have

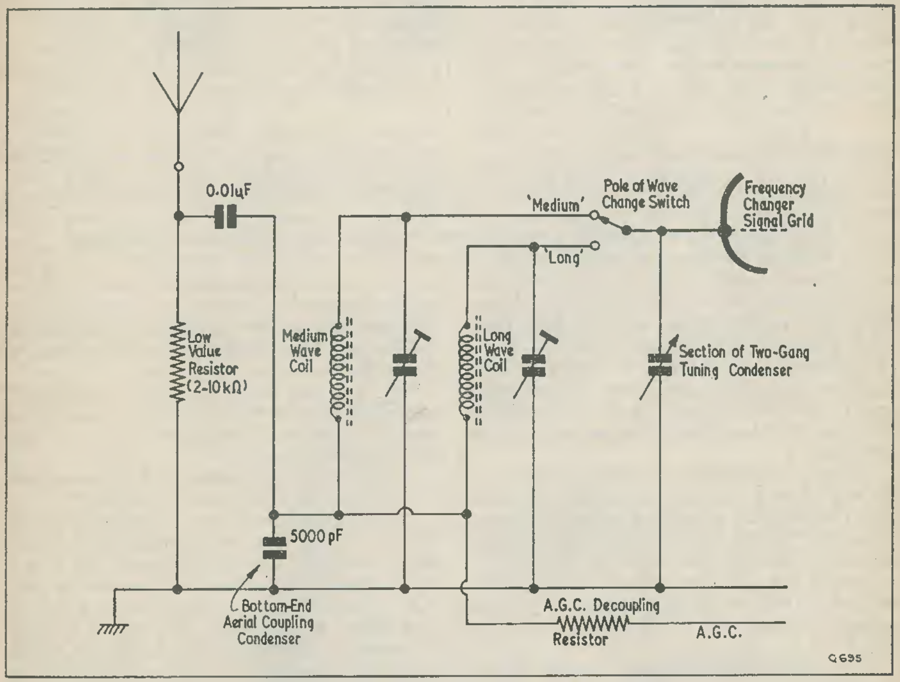


Fig. 1. A typical Medium and Long wave bottom-end coupled aerial circuit. The value given for the bottom-end coupling condenser (5,000pF) is typical of normal practice

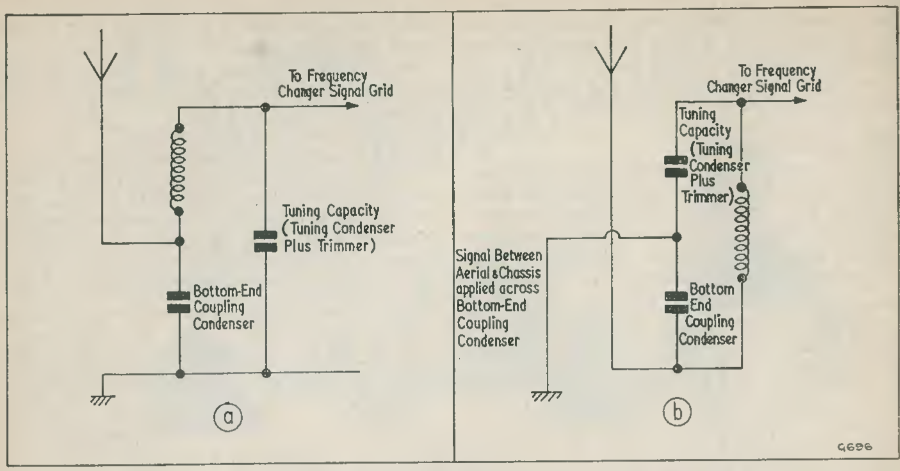


Fig. 2 (*a*). *The bottom-end coupling circuit can be reduced to the simple form shown here*

(*b*). *This diagram, which is a rearrangement of* (*a*), *shows how the signal voltage between aerial and chassis is fed into the capacitive half of the tuned circuit*

developed shorted turns at the same time. What's the set like with an aerial?"

"Fairish," said Dick. "I get the local stations reasonably well, and on the right part of the dial. There's a bit of a whistle with one of them which changes as you tune through."

"That", commented Smithy, "will be a second channel whistle, because the aerial tuned circuit isn't selecting the required signal properly. Have you checked the 5,000pF condenser between the coils and chassis?"

"Well, it's got no *shorts* in it," Dick replied, "because there's an a.g.c. voltage getting through to the frequency changer grid."

"Try changing it anyway," said Smithy shortly.

Obediently, Dick found a replacement condenser and soldered it into circuit.

"I had a shocking repair job to do last night," said Smithy chattily, as he watched Dick replacing the condenser.

"Oh, yes," remarked Dick. "What was it?"

"Just a record player," said Smithy carelessly. "And it didn't respond to *any* of the normal treatment. Ah, I see you've got that new condenser fitted in now. Let's see how the set behaves."

Dick switched it on.

"Well, I'm dashed," he exclaimed after a moment. "The Medium and Long wave coils are trimming perfectly now!"

"And so they should," remarked Smithy. "But that condenser I replaced just now was just an a.g.c. decoupler," protested Dick. "How on earth could it affect the tuning of the coils?"

"It was not only an a.g.c. decoupler," corrected Smithy. "It was also a bottom-end aerial coupling condenser. And it had undoubtedly gone o/c."

"A *coupling* condenser," Dick ejaculated, "with one side connected to chassis?"

"A coupling condenser," repeated Smithy firmly. "Now let's take a closer look at that input circuit. The arrangement used is a conventional bottom-end coupled aerial input circuit, and the aerial connects, via a 0.01µF condenser, to the upper plate of the 5,000pF component you've just replaced. Also connected to this condenser are the bottom ends of the Medium and Long wave coils, their top ends being selected by one pole of the wavechange switch. You will notice that there are no aerial coupling coils."

"Then how does the aerial signal get in?"

"Because of the bottom-end coupling condenser." Smithy picked up a pencil and started to scribble in Dick's notebook. "If you cut out the wavechange switch and some of the other components you will find that the circuit boils down to this. (Fig. 2 (*a*).) Which is exactly the same as this. (Fig. 2 (*b*).) Do you see how it works now?"

"It's coming a bit clearer," admitted Dick. "The bottom-end coupling condenser is really part of the capacity tuning the coil. One way of feeding an aerial signal into a tuned circuit is to apply it to a tap in the coil. With bottom-end coupling you apply it to a tap in the capacity! The fact that the aerial and earth inputs are upside-down doesn't matter, because you still have the same signal input voltage between these two points."

"That's exactly right," confirmed Smithy. "Also, you get a voltage step-up effect which is similar to that given by tapping into the coil. The step-up depends upon the ratio between the reactance of the overall tuning capacity—that is, the bottom-end condenser in series with the tuning and trimming capacity—and the reactance of the bottom-end condenser itself."

"Won't that ratio change as the tuning condenser is adjusted?"

"Definitely," replied Smithy, "and that's a snag with bottom-end coupling. Although it doesn't cause a lot of trouble in practice."

"What are the advantages of bottom-end coupling?"

"Well," said Smithy, "there are several important advantages. First of all you do away with a coupling winding on each coil, and this reduces coil manufacturing costs. Also, you only need one wavechange switch pole, as there are no coupling windings to switch."

"What about Short waves?"

"A bottom-end coupling condenser value suitable for Medium and Long waves," replied Smithy, "isn't much good for Short waves. But you can still add a Short wave range easily enough. All you do is to put the Short wave coupling winding in series with the feed to the bottom-end condenser. (Fig. 3.) Since the Short wave coupling coil consists of a few turns of wire only, it doesn't have any effect worth writing home about on the Medium and Long wave circuits. Further, you can switch the grid coil and still retain your single wavechange switch pole."

"That's ingenious."

"It *is* a neat circuit," agreed Smithy. "And you will find it in most Long, Medium and Short wave receivers having bottom-end aerial inputs. Incidentally, a snag with bottom-end coupling is that the aerial input impedance is so low that you have to have an earth connection to the chassis to get any reasonable signal input. So, bottom-end aerial input circuits are used normally with mains receivers only."

"I don't get that," said Dick, puzzled. "Why only mains sets?"

"Because mains receivers are automatically connected to the earth provided by the mains wiring in the house or building. This wiring doesn't usually give a very good earth, admittedly, but it serves the purpose. If the receiver is an a.c./d.c. job the chassis will be connected directly to the mains wiring. If it's an a.c.-only job it will be connected to the mains wiring via the self-capacity in the

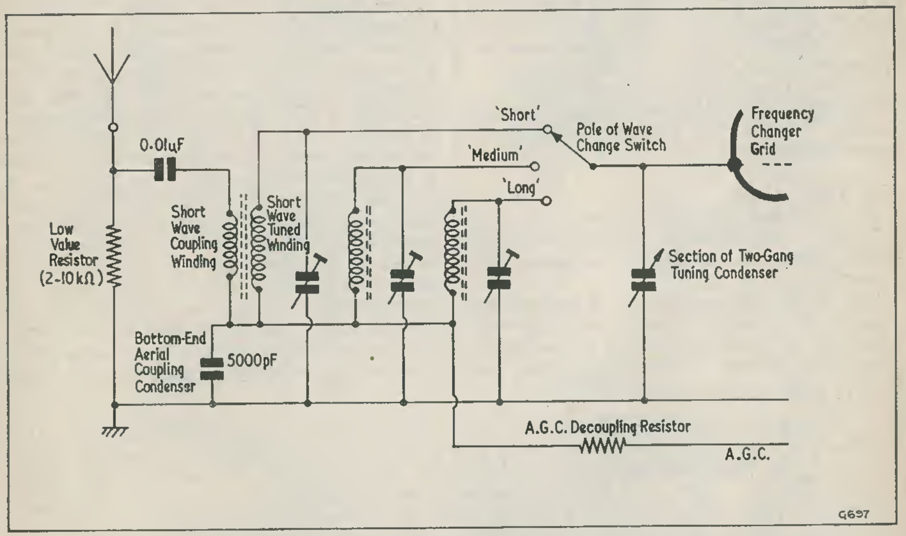


Fig. 3. *Adding a Short wave range to the circuit of Fig.* 1. *The coupling winding of the Short wave coil is inserted in series with the aerial feed to the bottom-end coupling condenser, and its low inductance has little effect on Medium and Long wave performance. At the same time, the bottom-end coupling condenser provides a low reactance circuit to chassis for the lower ends of the Short wave coupling and tuned windings* mains tranny. In the latter instance the designer may, however, have added an anti-mains modulation condenser between one side of the mains and chassis, whereupon this condenser would also ensure that the chassis was effectively coupled to the mains wiring."

"There are one or two components in the circuit which puzzle me a little," confessed Dick. "What about the series 0.01μF condenser, for instance?"

"That's just an isolating condenser for use if the receiver is an a.c./d.c. job. It also prevents any voltages which appear accidentally on the aerial from finding their way on to the a.g.c. line."

"Fair enough," said Dick. "What's the low-value resistor between aerial and chassis for?"

"To prevent mains modulation of the input signal. The chassis may well have an a.c. mains voltage on it with respect to true earth and, if the aerial has a relatively large capacity to true earth, part of the a.c. voltage could appear across the bottom-end condenser. The low-value resistor very nearly short-circuits this a.c. voltage, whilst still offering a reasonably high impedance at r.f. It also very nearly short-circuits any hum voltages picked up by the aerial in the normal course of events. Unfortunately, it is difficult to give this resistor too low a value or you begin to lose aerial signal strength. Modulation hum is still possible, therefore, in the worst cases; as could occur if an aerial having a very large capacity to true earth were used with an a.c./d.c. receiver whose chassis happened to be connected to the live side of the mains."

"What's the solution to *that* problem?"

"Reverse the receiver mains plug," grinned Smithy, "so that the receiver chassis is at neutral potential."

T.V. Tuner Units

Dick digested this information.

"Aren't bottom-end coupling circuits getting rather old fashioned?" he asked after a moment.

"So far as the manufacture of a.m. sound receivers is concerned, yes," said Smithy. "Because it's more convenient nowadays to use ferrite frames. Nevertheless, there are plenty of bottom-end aerial input receivers in use, and there are plenty which pass through the hands of service engineers. Don't forget, by the way, that bottom-end aerial coupling has been a fairly recent innovation on t.v. tuners."

"Come again?"

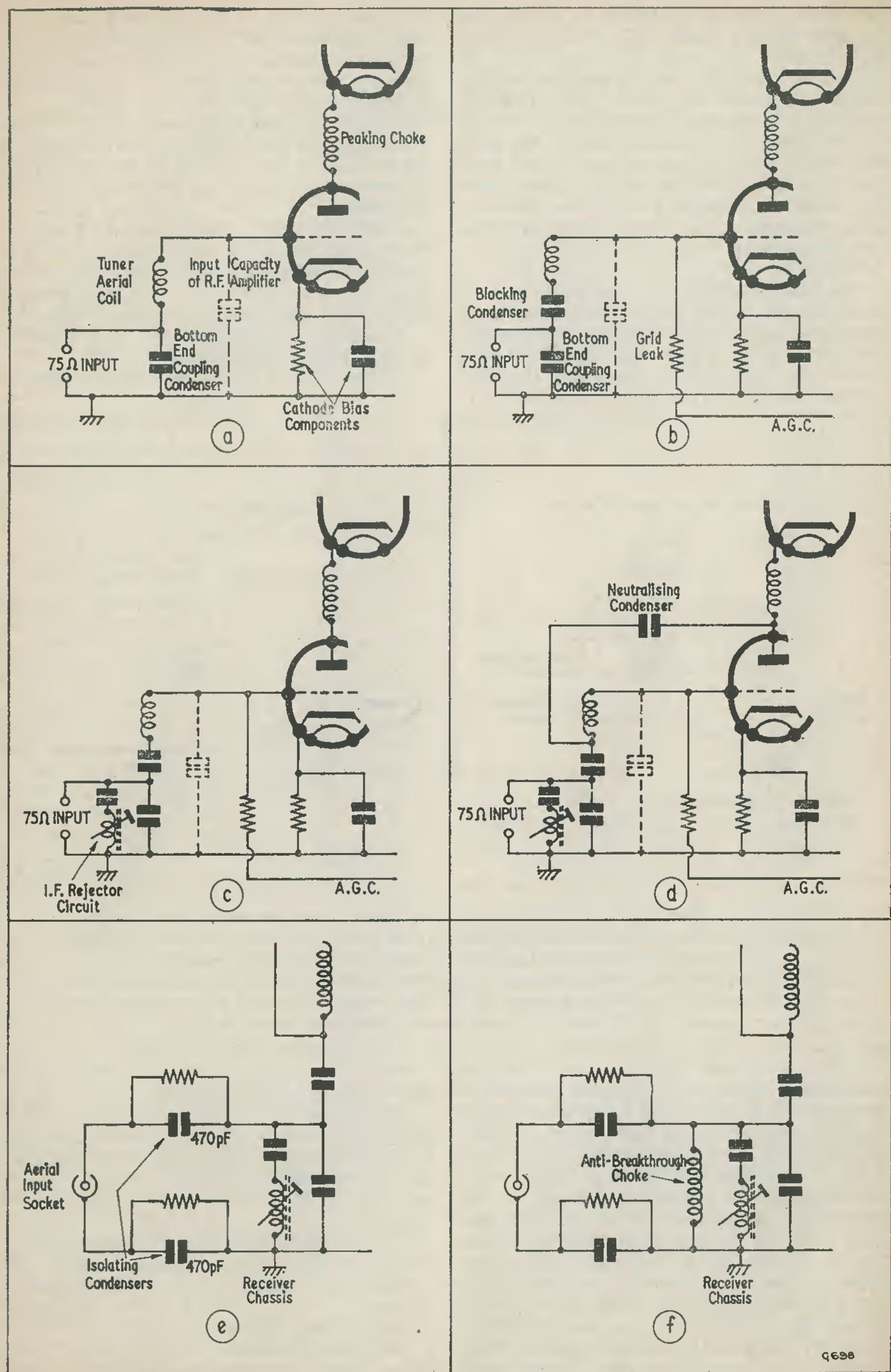
"You heard me. There are plenty of t.v. tuners knocking around these days with single-winding aerial coils. How do you think the aerial signal gets into them?"

"I've never really understood," confessed Dick. "When I look at the circuit diagrams of these tuners in the service manuals I see such a conglomeration of components around the aerial coil that I usually try and forget about them!"

"The circuits are quite simple really," said Smithy, "and they all start off with a basic bottom-end circuit like this (Fig. 4 (*a*).) Once again, you get a step-up effect like you had with the Medium and Long wave circuit, only in this case the total capacity across the coil is given by the bottom-end condenser in series with the input capacity of the r.f. amplifier valve. And, of course, you don't have a variable tuning condenser. You have, instead, a different coil presented to the circuit for each channel. Incidentally, the step-up given by the circuit is, in this case, that needed to match the 75Ω impedance of the aerial to the input impedance of the valve.

"Normally", continued Smithy, "you want to apply a.g.c. to the valve, and so it's usual to put a blocking condenser and leak in the grid circuit. (Fig. 4 (*b*).) Compared with an input circuit using a coupling winding, the bottom-end input circuit has the disadvantage of leaving the grid rather wide open to the aerial, and so an i.f. rejector has to be added to prevent breakthrough. Here it is (Fig. 4 (*c*)), connected right across the input terminals. Oh, and there's neutralisation too, because the first valve in the tuner is almost bound to be a triode, this probably being part of a cascode. If you think about it you'll realise that the two ends of the coil are certain to be 180 degrees out of phase with each other at resonance, with the result that the neutralising condenser can be taken

Fig. 4 (a). The basic input circuit of a television tuner using a single winding aerial coil. The triode shown here is part of a double-triode cascode r.f. amplifier
(b). In order that a.g.c. may be applied to the valve, it is necessary to add a blocking condenser and grid-leak
(c). An i.f. rejector circuit is required also, to prevent breakthrough.
(d). A further component is a neutralising condenser
(e). The aerial isolating condensers. These appear between the "75Ω input" of (d) and the actual aerial socket. The resistors across the condensers have high values (around 2MΩ) and prevent the formation of static voltages on the aerial
(f). The final component is a choke after the isolating condensers. This prevents Medium and Long wave breakthrough



from the anode of the triode to the end of the coil remote from grid. (Fig. 4 (*d*).) O.K. so far?"

"I understand all the components you've added up to date," said Dick. "But I've still seen more in practical circuits!"

"I won't argue," replied Smithy, "so let's add the aerial isolating condensers and their parallel resistors. (Fig. 4 (*e*).) Now, you may find it surprising but the isolating condensers are liable to allow Medium or Long wave breakthrough to occur!"

"Hey?"

"Nothing less! Should you have a long co-ax downlead and live in an area of high signal strength, the downlead can pick up the local Medium or Long wave signal. If you assume, for the sake of argument, that the

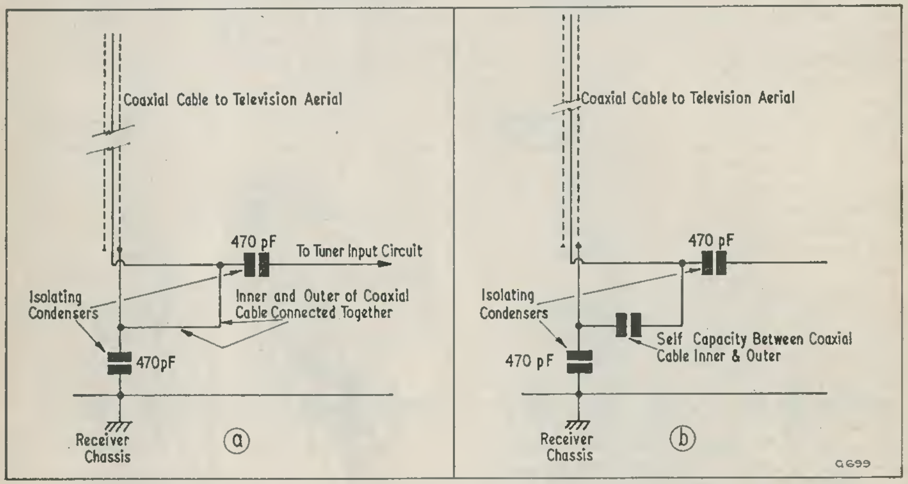


Fig. 5 (a). Showing how Medium and Long wave breakthrough is possible in a television tuner using a single aerial coil circuit. It is assumed here that the inner and outer conductors of the coaxial cable are connected together

(b). If the coaxial inner and outer conductors are not connected together they are still coupled by their self-capacity. In this instance the undesired signal would be largely picked up on the outer conductor

co-ax inner and outer conductors are short-circuited for Medium and Long waves then this signal is applied to the junction of the two 470pF isolating condensers. (Fig. 5 (*a*).) Quite a bit of the breakthrough signal will, obviously, find its way on to the grid of the first triode. In practice the co-ax inner and outer will only be connected together if you have a folded dipole sitting amongst the chimney pots but, even if the conductors aren't shorted together, their self-capacity will still be sufficiently high to allow the effect to occur. (Fig. 5 (*b*).) You overcome the trouble by adding a choke after the isolating condensers. (Fig. 4 (*f*).) This choke has a high impedance at t.v. frequencies, and a very low impedance at Medium and Long waves. The latter are, in consequence, shorted down to deck."

"Ah," said Dick with satisfaction. "Your final circuit is just about the sort of thing I see in Service manuals. And so that's how bottom-end coupling has found its way into t.v. tuners!"

"That's right," said the Serviceman. "Only this time it's usual to refer to the circuit immediately around the coil as a pi input circuit. The name's obvious enough if you draw the coil horizontally." (Fig. 6.)

A sudden thought crossed Dick's mind, and he changed the subject.

"What were you saying about a record player you serviced last night?"

"I only said it was a shocker," replied Smithy. "As a matter of fact, the first snag I had with it was wow. You could almost *see* the variation in turntable speed. I had to clean up all the mechanical drive to the turntable."

"The synchronous motor," observed Dick. "Couldn't have been doing much good."

"This one didn't have a synchronous motor."

Dick looked interested.

"But don't you need a synchronous motor if you're running from the mains?"

"This one didn't get its power from the mains," said Smithy gravely. "It was a portable."

"Don't tell me it was one of those miniature battery jobs," said Dick excitedly. "Do you know, I've been trying to have a go at one of those for ages! How many speeds did it have?"

"Just the one."

"I know," enthused Dick. "It must be one of those 45 r.p.m. players. What did you do after you cleared the wow, Smithy?"

But the Serviceman was already moving back to his own bench.

"I can't stand here nattering all day," he complained. "We've got work to do."

And, deaf to his assistant's protests, he immersed himself in his work.

Soldering Litz Wire

The Serviceman was to be left in peace for five minutes only.

"Smithy."

"Hello!"

"Can you just give me a bit of quick advice about this solder joint?"

The long-suffering Serviceman followed the well-trodden path to Dick's bench, where the a.m. sound receiver still lay.

"Dash it all," exploded Smithy, "haven't you finished that set *yet?*"

"I'm sorry, Smithy," said Dick contritely, "but when I worked on this set I removed some of the leads from the Medium wave coil. These were on the same tag that carried the litz wire from the winding. I'm a bit scared to solder the wires back now, in case I break any of the strands of the litz."

Smithy examined the tag.

"I don't blame your feeling worried about it," he remarked sympathetically. "What's happened here is a fairly common occurrence. When you first handle the connections to a tag of this nature, the litz wire is wrapped around it correctly and seems to be beautifully soldered. However, when subsequent soldering operations are carried out the litz joint suddenly starts to look unhealthily cold, and all the litz wire strands appear oxydised and brittle. Whenever I encounter a tag with litz wire soldered to it I try to leave it severely alone for exactly this reason. If I have to take away a wire which has been clenched on to the tag close to the litz I normally snip it. If I have to add a wire at the same point as the litz I do the soldering as quickly as possible."

"What exactly," asked Dick, "is the purpose of litz wire?"

Smithy sighed. Dick's fund of questions was like the widow's cruse.

"Well," he replied, "you have to remember that r.f. currents tend to travel on the surface of conductors. Litz wire has a lot of conductors all interwoven together, with the result that you get a larger surface area for the r.f. to travel on than you would with a single round conductor of the same overall diameter. Also, the interweaving causes the strands in the litz wire to go in and out of the centre of the wire, and this forces some of the r.f. current to pass through the centre of the group of strands instead of on the outside ones only. The result is a further advantage over the round conductor. In actual fact, many of the multi-strand wires used for winding coils these days don't use the true litz formulation at all. Instead, they are what are called 'bunched' wires, this being a version which is cheaper to make and which gives, so far as I know, more or less the same results."

"Do all litz or bunched wires have a cotton or rayon outer covering?"

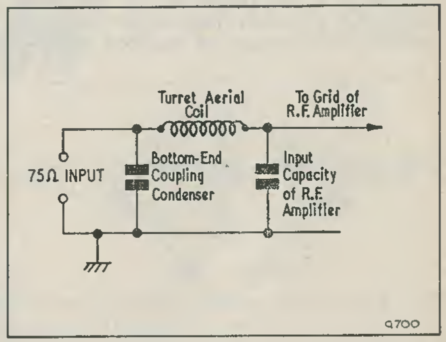


Fig. 6. When the tuned circuit components of Fig. 4 (a) are re-drawn as shown here they may be recognised as providing a pi coupling circuit

"Not necessarily," said Smithy. "It is essential, to start off with, that the strands in litz wire be insulated from each other, and this is normally done by using enamel insulation on the strands. The whole is then covered by a single, or double, rayon outside covering. Incidentally cotton, or natural silk for that matter, is rarely used nowadays for the outside covering of litz wire or any other enamelled winding wire. Rayon is cheaper. Some litz wires have no outer covering at all, the strands being held together sufficiently well for coil winding by passing them through an impregnating wax. Wire of this nature is known as 'waxed litz', and you occasionally encounter it in 465 kc/s i.f. transformers and the like."

"Talking of outside coverings," queried Dick, "I've sometimes heard people refer to 'art silk'."

"In this application," said Smithy, "art silk is rayon."

"How do they manage to solder all the strands of litz wire in the factory?"

"In the old days," said Smithy, "the enamel on the individual strands had to be burned off. The wire ends of a coil were pre-tinned before connection to the tags by initially passing them through a flame until the wire became red-hot. The red-hot wire was immediately doused in methylated spirits, and then just as quickly plunged into a heated pot full of molten solder. Once you got the knack of it, this process gave beautiful tinning."

"Didn't the meths ever catch fire?"

"Often! It was kept in a container with a hinged lid which could be flipped down if the meths caught alight, and thereby save ulcers in the insurance company. A funny thing about this process was that it was a once-only job. If you failed to tin the strands properly first go, you'd had it. The same length of wire would rarely tin on the second attempt. Modern litz, or bunched wire, has

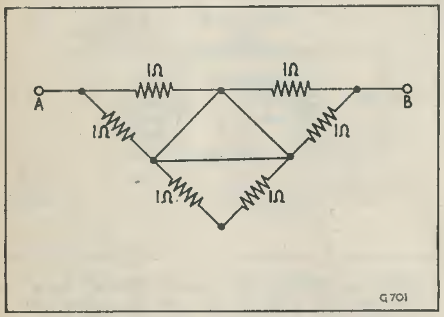


Fig. 7. Smithy's simple problem. What is the resistance between terminals A and B?

self-soldering enamel on the strands. This enamel melts at soldering temperatures, so you can either solder all strands on the tag itself or, preferably, pre-tin the wire end by dipping it in a pot full of molten solder."

"What frequencies is litz wire O.K. for?"

"Rough check," replied Smithy, "from some 200 kc/s or so up to 5 or 6 Mc/s. Outside these frequencies litz wire offers hardly any advantages over ordinary round conductors."

Smithy's Service Job

Dick was quiet for a moment.

"I hate to go back to that record player of yours," he remarked, "but I'm still completely fascinated by it. What else was wrong with it?"

"One thing I noticed", replied Smithy, "was that stylus wear was absolutely terrible. You may not believe this, but I actually had to change over to a new stylus after playing only one side of a record."

Dick's eyes rounded.

"Phew, that was a *snag!*" he remarked. "Someone must have been cleaning up the pick-up with impact adhesive."

"Well, I didn't find anything like that," said Smithy, beginning to walk away. "And I must, for the second time this morning, remind you that I cannot stand here gassing all day long."

"Just satisfy a *little* more of my curiosity," pleaded Dick. "Was the output distorted?"

"It sounded pretty rough to me."

"At all volume levels?"

"There was only one volume level available," remarked Smithy soberly.

"Wasn't there even a volume control?"

"Nope."

"Then how did you control volume?"

"You didn't."

"Oh, come off it, Smithy," said Dick indignantly. "You can't *possibly* have a record player without a volume control!"

"This particular model", remarked Smithy, ignoring Dick's protests, "only comes on when the stylus is placed on the record."

"Well, that *is* a neat idea," said Dick enthusiastically, forgetting the lack of volume control for the moment. "I wonder what designers will think of next!"

But even Dick's fertile imagination was becoming unequal to the task of rationalising the picture conjured up by Smithy's words.

"You've just *got* to show me this gadget," he said eventually. "It sounds to me like the very *latest!*"

"Well, it was considered pretty modern when it was made," remarked Smithy. "Around about 1930, I think it was."

Dick's mental image crashed about him in ruins.

"Why, you rotten devil," he cried, "you were talking all the time about an old-fashioned acoustic wind-up gramophone!"

"Of course I was," laughed Smithy. "It was you who made all the assumptions."

"But you said it only played one speed!"

"So it does. 78's."

Dick thought back for a moment.

"And there was I", he said remorsefully, "getting really worked up about it. What a mug!"

"Not to worry," chuckled Smithy. "That makes two of us today."

Smithy's Problem

A thought crossed Smithy's mind.

"Before I leave", he said, "I've just remembered that I've got one of my little problems for you. This time, it's a dead easy one too."

"I'll take your word for it," said Dick cautiously. "Let's hear it."

"The problem goes like this," replied Smithy. "Between two terminals A and B you have six 1Ω resistors arranged in a triangular pattern with interconnecting wires. (Fig. 7.) What's the resistance between terminals A and B?"

"Well, that shouldn't take long," said Dick, seizing paper and pencil. "I'm going to start on it right away."

"Oh no you're not," replied Smithy. "You've still got that set to clear up yet. I'll give you the answer next time we meet. And don't forget, this one's a piece of cake!"

UNDERSTANDING TELEVISION

PART 39

By **W. G. MORLEY**

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

In last month's article we completed our discussion of power supply circuits. We shall now carry on to the last subject to be dealt with in this series: television receiver aerials.

The Television Receiver Aerial—the Dipole

The function of a receiver aerial is to pick up the signal radiated by the transmitter and cause it to be applied to the input terminals of the receiver. At the transmission frequencies encountered in television, it is readily possible for the receiver aerial to be given dimensions which allow it to be *tuned* to the frequency being received, thereby ensuring that a relatively high level of pick-up, at the desired frequency, is achieved.

Fig. 233 (*a*) illustrates a conductor whose length is approximately half that of a wavelength of the transmitted signal. The Greek letter λ (lambda) used in this diagram is that commonly employed to represent wavelength. When placed in the field of the transmitted signal the half-wavelength conductor exhibits the current and voltage distribution illustrated in the diagram. It will be noted that voltage in the conductor is greatest at the ends and that current is greatest at the centre. It is possible to obtain a signal from the conductor for application to a receiver by tapping into two points along its length, the taps being equi-spaced about its centre. If we were to do this we would find that the impedance at signal frequency presented by the conductor at the taps would increase as the latter moved away from the centre, the impedance rising to several thousand ohms at the ends. To obtain optimum results, it would be necessary to ensure that the receiver input impedance was matched to that appearing across the taps, and that the wires connecting to the taps did not modify the manner in which the conductor responded to the signal.

An alternative, and much simpler, method of extracting the signal from the half-wavelength conductor consists of breaking it at its centre and connecting the two inside ends to the receiver, as in Fig. 233 (*b*). The impedance at the two inside ends of the conductor will be approximately 75Ω, and it would be necessary for the receiver input circuit to present this impedance to the conductor if correct matching was to be achieved.

Fig. 233 (*b*) illustrates a working arrangement for picking up the signal to which the half-wavelength conductor is tuned, and we may now refer to the conductor as an aerial. An aerial of this type is known as a *dipole*, and it forms the basic element of a large number of television aerial designs.

In order that the manner in which a dipole becomes tuned can be more readily understood, it may prove helpful to consider it in the light of its own self-inductance and self-capacity. The dipole could, therefore, be depicted as shown in Fig. 233 (*c*), in which the conductor is represented by a series of coils representing its own self-inductance, and the self-capacity by a series of condensers between points on opposite sides of the centre. Fig. 233 (*c*) provides a simplified picture of the self-inductance and self-capacity. Actually, the number of "coils" and "condensers" is infinite.

Fig. 233 (*b*) illustrates the dipole connected directly to the receiver input terminals. In practice the receiver has to be positioned some distance away from the dipole, whereupon it becomes necessary to provide a means of coupling the two together which will not upset the impedance matching between them. The coupling is provided by a two-conductor *feeder* having a *characteristic impedance* equal to that at the centre of the dipole and the input terminals of the receiver. See Fig. 233 (*d*). Under these conditions the feeder presents the same impedance to the dipole as is given by the input terminals of the receiver. Similarly, it presents the same impedance to the receiver as is given by the dipole. We shall discuss

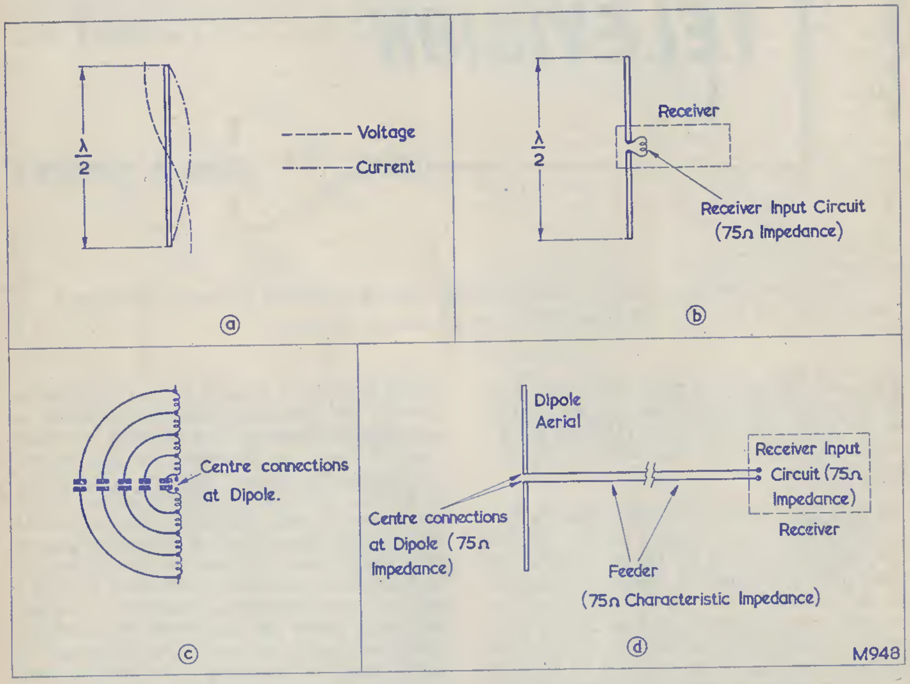


Fig. 233. (a) If a conductor in the field from a transmitter has a length approximately equal to half a wavelength of the transmitted signal the voltage and current distribution shown here is built up

(b) When the half wavelength conductor is broken at the centre it forms a dipole aerial. It is shown here connected directly to the input circuit of the receiver (depicted as a coupling coil)

(c) The dipole becomes tuned by reason of its own self-inductance and self-capacity

(d) It is normally impracticable to couple a dipole aerial direct to a receiver, as was illustrated in (b). The two are coupled together, therefore, by a two-conductor feeder having a characteristic impedance equal to that at the centre connections of the dipole and at the input circuit of the receiver

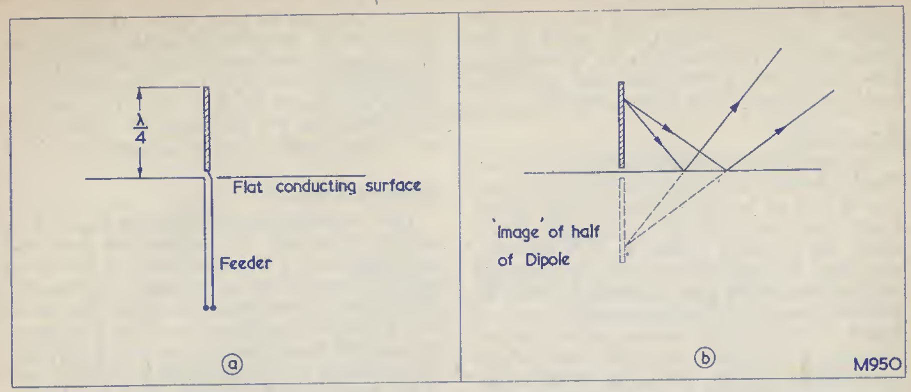


Fig. 234. (a) An aerial employing a quarter wavelength conductor mounted above a flat conducting surface. The feeder wire connecting to the conductor may conveniently be taken through a hole in the conducting surface

(b) Due to the reflecting properties of the flat conducting surface, an "image" of a dipole member is formed below it in the manner shown here

the eeder in more detail later.

The length of a dipole used at television frequencies is equal to a half-wavelength multiplied by a factor *k*. Since wavelength in metres multiplied by frequency in Mc/s equals 300, the dipole length may be conveniently expressed as follows:

$$\text{length (in metres)} = \tfrac{1}{2} \times \frac{300 \times k}{\text{Freq. (Mc/s)}}$$

Simplifying, and converting to inches (by multiplying metres by 39.37), this becomes:

$$\text{length (in inches)} = \frac{5906 \times k}{\text{Freq. (Mc/s)}}$$

The factor *k* varies according to the ratio between a half-wavelength and conductor thickness. It is always less than unity, and for most television receiving applications can be taken as being 0.94 to 0.95. The fact that the dipole is always shorter than an actual half-wavelength is due to "end-effect", this being an additional capacitive loading appearing at the ends of the dipole members.

The bandwidth of the dipole increases with the diameter of its conductors. Bandwidth may be expressed in terms of the frequency variation on either side of centre frequency which causes the signal voltage passed to the receiver to drop by 3dB. A television signal occupies a wide band of frequencies and the bandwidth of the aerial has, in consequence, to be sufficiently great to ensure that all frequencies in the signal are passed to the receiver without undue attenuation. To obtain the relatively wide bandwidth required, television dipoles usually employ metal tubing having diameters of the order of half an inch.

It is possible to dispense with the lower half of a dipole by mounting the upper section immediately above a flat conducting surface, as in Fig. 234 (*a*). The surface functions as a reflecting medium (not to be confused with reflector elements, which will be considered shortly) and "reflects" the upper half of the dipole, as shown in Fig. 234 (*b*). With this arrangement, the feeder connects to the lower end of the upper dipole section and to a point on the conducting surface immediately below, the impedance between these two points being roughly half that given by a dipole. This type of aerial is known as a *quarter-wave aerial* and it finds occasional application for television reception. It should be pointed out that the flat conducting surface need not be continuous; it may consist of wire mesh or of a number of metal rods radiating out from the centre. Normally, the feeder wire connecting to the conducting surface would connect to earth, or chassis, at the receiver end.

Since a tuned aerial designed to pick up signals at a particular frequency or band of frequencies offers the same characteristics when it is required to *transmit* such frequencies,[1] terms normally encountered in transmitting theory are frequently encountered when receiving aerials are referred to. As we shall see, shortly, the simple dipole we have just referred to may have other tuned conductors placed close to it to modify its performance. In this instance the dipole may be referred to as the *driven element*, because it is the element to which the transmitter

[1] Providing, of course, that its conductors can carry the heavier currents which flow, and its insulation can stand up to the higher voltages.

output is applied and which is, in consequence, "driven". Again, the feeder to the dipole may be referred to as the *transmission line*, since it is via the feeder that the transmitter connects to the driven element.

Polarisation

If a television transmitter employs a vertical dipole transmitting aerial the signal it transmits is said to be *vertically polarised*. If the transmitter employs a horizontal dipole aerial the signal it transmits is *horizontally polarised*. To receive a vertically polarised signal the receiving dipole should similarly be mounted vertically. A horizontally mounted dipole is required for horizontally polarised signals. In Britain, television signals are vertically polarised[2] whilst, in other countries, such as the U.S.A., horizontal polarisation is employed.

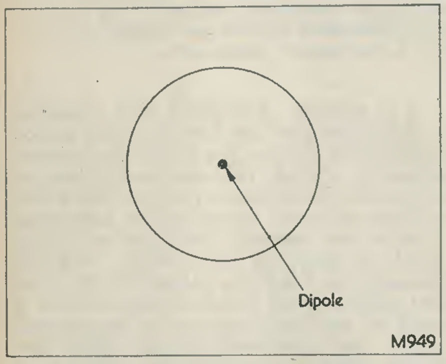


Fig. 235. The horizontal polar diagram of a vertical dipole is a circle, because the aerial has equal sensitivity in all directions in the horizontal plane

Unless otherwise stated, all the aerials discussed here are shown in the appropriate diagrams as being vertically polarised.

Polar Diagrams

A polar diagram is employed to illustrate the efficiency of an aerial in a given plane. It consists of a circular chart on which is drawn a graph indicating signal strength at all points around the aerial, assuming that a transmitter of constant output is connected to it. (Conversely, the graph indicates the transmitted signal strength required at all points round the aerial to cause a constant signal strength to appear in a receiver connected to it.) The zero point for the graph is at the centre of the chart.

[2] With the exception of a few transmitters which radiate horizontally polarised signals.

We have, up to now, considered a single dipole aerial mounted vertically. Its polar diagram in a horizontal plane taken through the centre of the dipole would consist of a circle, as shown in Fig. 235, because the aerial receives (or transmits) at equal level in all directions in the horizontal plane.

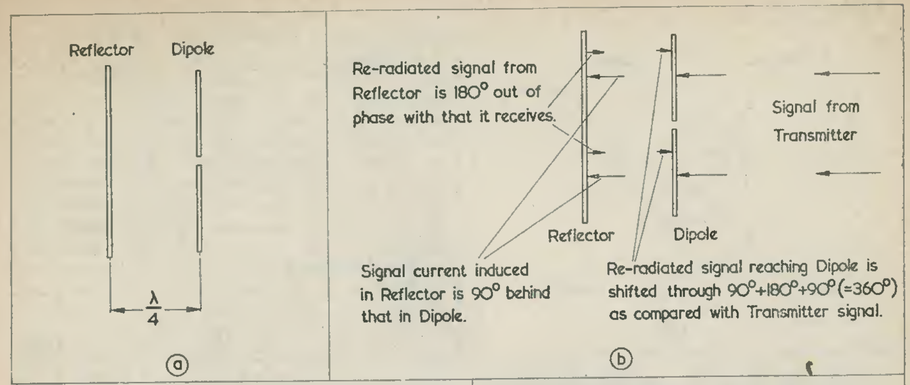
Adding a Reflector

The omnidirectional performance of a simple dipole may be considerably modified by positioning a reflector close to it. In its simplest application, a reflector consists of a conductor having approximately the same length as the dipole and mounted a quarter-wavelength away from it, as in Fig. 236 (*a*). The reflector is a continuous conductor and is not broken at the centre, as is the dipole.

Fig. 236 (*b*) shows the effect given by the dipole and reflector combination when the transmitter is on the opposite side of the dipole to the reflector. The signal from the transmitter causes currents to appear in both the dipole and the reflector. Since the reflector is a quarter-wavelength behind the dipole, it receives its signal one quarter of a cycle later. In consequence, the signal current in the reflector lags 90° behind that in the dipole. Due to the currents flowing in it the reflector re-radiates a signal which is 180° out of phase with that it receives from the transmitter. This re-radiated signal is picked up, after a further delay of a quarter of a cycle due to the quarter-wavelength spacing, by the dipole. The overall effect is as follows: the signal current in the reflector is firstly 90° behind that in the dipole, the re-radiated signal is 180° out of phase with that from the transmitter, and a further 90° delay takes place before the re-radiated signal is picked up by the dipole. The signal picked up by the dipole via the reflector has, therefore, been shifted through 360°; with the result that it is in phase with that picked up directly from the transmitter, and augments it.

If, as in Fig. 236 (*c*), the transmitter is on the same side of the dipole as the reflector a different effect takes place. To commence with, the signal current in the *dipole* is now 90° behind that in the reflector. As before, the reflector re-radiates a signal that is 180° out of phase with that it picks up from the transmitter. When this re-radiated signal arrives at the dipole it, also, is 90° behind that at the reflector and is, in consequence, 180° out of phase with that from the transmitter. Instead of augmenting the transmitter signal picked up by the dipole, the re-radiated signal now causes it to be diminished.

A typical horizontal polar diagram for a vertical dipole fitted with a reflector is shown in Fig. 237 (*a*). It will be noted that this differs considerably from that of the dipole



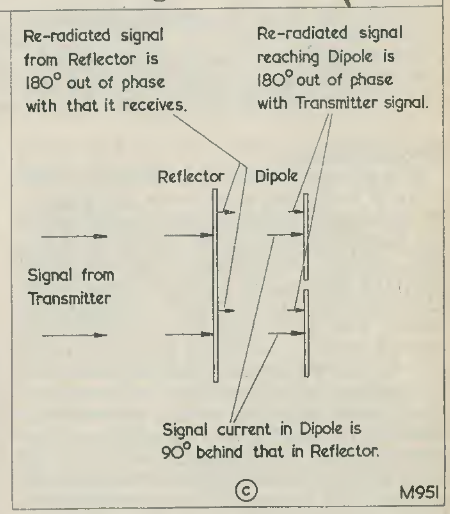


Fig. 236. (a) A simple reflector and dipole combination. The reflector is mounted in the same plane as the dipole and is a quarter wavelength behind it (b) When the transmitter is on the dipole side of the combination, the reflector augments signal strength in the dipole (c) When the transmitter is on the reflector side of the combination, signal strength in the dipole is diminished

on its own which was given in Fig. 235. Along the line OA—on the side opposite to the reflector—the curve indicates maximum sensitivity. Along the line OD—on the same side of the dipole as the reflector—the curve indicates minimum sensitivity. It should be noted, also, that the sensitivity along line OA is greater than that at any point around the single dipole because of the signal-augmenting effect of the reflector.

Two important advantages are provided by the reflector. The first of these is that sensitivity in the desired direction (along line OA in Fig. 237 (*a*)) is increased. The second is that sensitivity to signals from the reflector side of the dipole is considerably reduced. The aerial becomes directional in consequence. It will be seen from the polar diagram of Fig. 237 (*a*) that the angle over which minimum sensitivity is given is much sharper than that over which maximum sensitivity occurs. In areas where interference from a particular well-defined direction is troublesome, it is often possible to position the dipole and reflector combination such that the reflector is interposed between the dipole and the source of interference, as in Fig. 237 (*b*). In Fig. 237 (*b*) the dipole and reflector combination is not directed at the desired transmitter, but the signal strength picked up by the dipole is only slightly lower than that which would be given if it were so directed. At the same time, the signal from the interfering source is reduced to a minimum. In consequence, the highest signal-interference ratio which can be given by the dipole and reflector combination is achieved.

It is common practice to refer to the *front-to-back ratio* of a directional aerial. In Fig. 237 (*a*) this ratio would be expressed by the ratio between sensitivity along the line OA and the sensitivity along line OD, and would be equal to OB:OC.

It is conventional practice to make the reflector longer than the dipole, and the detuning which results causes a complex phase relationship between the reflector and dipole to come into effect over the frequencies for which the aerial is designed. This relationship enables the reflector to be positioned closer to the dipole than the quarter-wavelength illustrated in the simple examples of Fig. 236. In practical assemblies, the reflector may be as close as one-tenth of a wavelength away from the dipole.

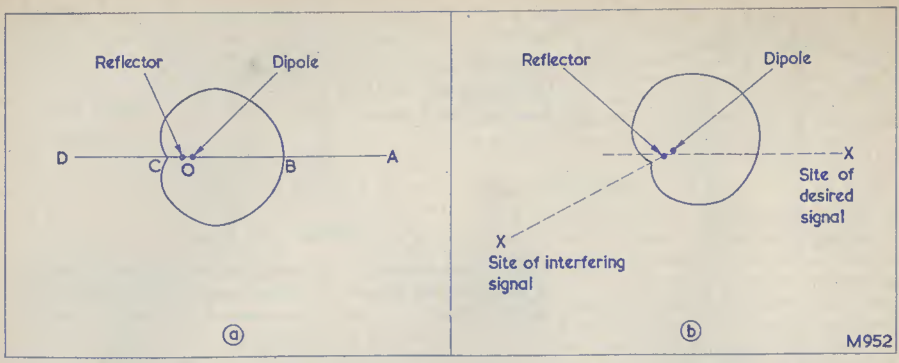


Fig. 237. (a) A typical horizontal polar diagram for a vertical dipole fitted with a reflector

(b) When the direction from which an interfering signal appears is well defined it is sometimes possible to rotate a dipole and reflector combination such that the reflector is interposed between the interfering signal and the dipole

Adding a Director

It is possible to further increase the sensitivity of a dipole and reflector combination by adding one or more tuned conductors on the *transmitter* side of the dipole, as in Fig. 238. Unlike the reflector, which is longer than the dipole. the directors are shorter. The directors may be spaced away from the dipole, and from each other, by distances varying between one-tenth and one-quarter of a wavelength, a spacing of approximately 0.15 wavelength being fairly representative of common practice. Adding a director or directors to a dipole and reflector combination causes the polar diagram of Fig. 237 (*a*) to be modified to the typical example shown in Fig. 239. As may be seen, sensitivity in the desired direction is increased as, also, is the front-to-back ratio.

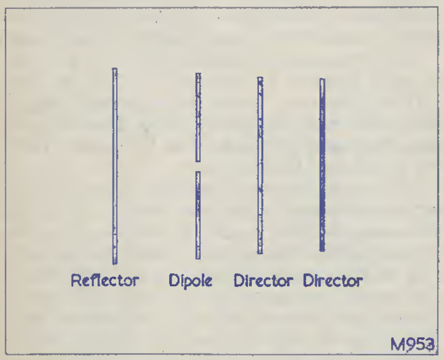


Fig. 238. One or more directors, which are shorter than the dipole, may be added on the opposite side to the reflector

Parasitic Elements—Impedance and Bandwidth

Because reflectors and directors are not directly connected to the receiver input feeder but modify, instead, the performance of the dipole, they are referred to as *parasitic elements*.

When parasitic elements are added to a dipole they cause the impedance at its two terminals to become reduced. A dipole fitted with a reflector can exhibit an impedance which may be as low as a half of that it would give on its own. If a director is added the impedance can be halved again. This effect is important, because it is desirable for television receiver aerials to match into standard feeder and receiver input impedances. In Britain the standard feeder and receiver input impedance is 75Ω, this enabling a good match to be made to a single dipole without parasitic elements. With careful design an adequate match to 75Ω feeder is still possible if a single parasitic element (either a reflector or a director) is added. If further parasitic elements are added to the dipole an accurate match to 75Ω feeder is difficult to achieve unless special matching arrangements are made at the dipole itself, or if the latter is changed to a folded dipole (shortly to be discussed).

The addition of parasitic elements also causes a reduction in bandwidth, and this factor necessitates especial care in aerial design for fringe areas wherein a relatively large number of directors, in addition to a reflector, may be required.

The Folded Dipole

Fig. 240 (*a*) illustrates a *folded dipole*. This, like the dipole we have already discussed, has an overall length which is equal to half a wavelength (less some 5 to 6% because of end effect). For television purposes the folded dipole has the advantage that the impedance at its terminals is four times that of a normal dipole. (Thus, the dipole of Fig. 240 (*a*) would exhibit an impedance of some 300Ω.) When a folded dipole is employed the impedance-lowering effect of parasitic elements can cause its relatively high impedance to drop such that a good match is provided to the standard British feeder and receiver input impedance of 75Ω. It is, in consequence, possible to add a relatively large number of parasitic elements to a folded dipole and still retain a good match to a 75Ω feeder.

The impedance of a folded dipole may be varied by employing a different thickness for the two conductors. If the unbroken conductor is thicker than the broken conductor (i.e. that to which the feeder connects) the impedance of the dipole increases. If the unbroken conductor is thinner than the broken conductor impedance decreases. When the two conductors have different thicknesses the impedance may be further altered by varying the distance between them. Increasing the distance between the conductors reduces the variation in impedance given by conductors of different thicknesses. Advantage may be taken of these points in the design of an aerial employing a large number of parasitic elements.

A *triple-folded dipole*, as shown in Fig. 240 (*b*), offers an impedance which is 9 times that of a normal dipole. This assumes that all conductor diameters are equal. Triple-folded dipoles are not normally employed in British television aerials, although they may have applications in countries where standard feeder and receiver input impedances are higher than 75Ω.

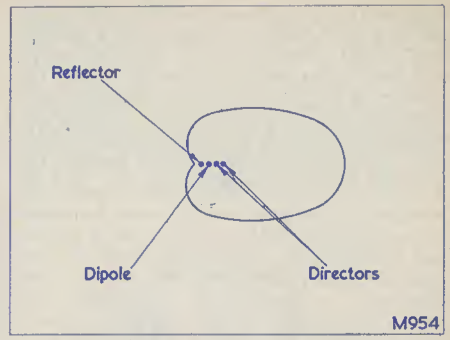


Fig. 239. Adding a director, or directors, to the dipole and reflector combination causes increased sensitivity in the desired direction, as is shown by this typical horizontal polar diagram

Aerial Gain

The performance of an aerial may be expressed in terms of *aerial gain*. This figure represents the increase in signal strength given by the aerial as compared with a normal dipole. The gain figure is a ratio and may be expressed in dB.

Practical "Outdoor" Aerials

Almost all "outdoor" television aerials employed in Britain are based on a dipole or folded dipole, with or without parasitic elements. In areas of good signal strength and low interference level a simple dipole is frequently all that is required for reception on Band I. Greater sensitivity on Band I is

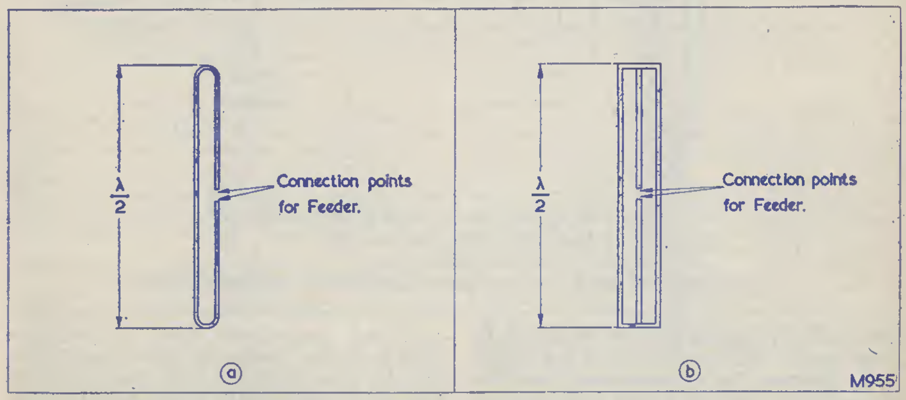


Fig. 240. (a) A folded dipole. This has an impedance four times that of a normal dipole

(b) A triple-folded dipole offers an impedance nine times that of a normal dipole

provided by the use of an "H" aerial (Fig. 241 (*a*)), and this may consist of a normal dipole and reflector, both elements being mounted on a metal cross-arm. Since the voltage at the centre of the reflector is at a minimum (see the current and voltage distribution for a half-wavelength conductor in Fig. 233 (*a*)) there is no need to insulate the reflector from the metal cross-arm, and an inexpensive mounting can be employed in consequence. The inner ends of the dipole have, however, to be insulated from the cross-arm, so that the feeder connection is not short-circuited. It is possible to add a director in front of the simple "H" aerial, but this causes difficulties in matching to the feeder unless special matching arrangements or a folded dipole are employed.

Band III aerials normally employ a folded dipole, a reflector and at least one director. (Fig. 241 (*b*).) The use of a folded dipole, with its initial high impedance, enables parasitic elements to be added far more readily than would be the case with a normal dipole. Once again a metal cross-arm is employed and, since there is minimum voltage at the centre of the reflector, the director (or directors) and the unbroken conductor of the folded dipole, none of these points needs to be insulated from the cross-arm. An insulated mounting is required only at the terminals of the folded dipole.

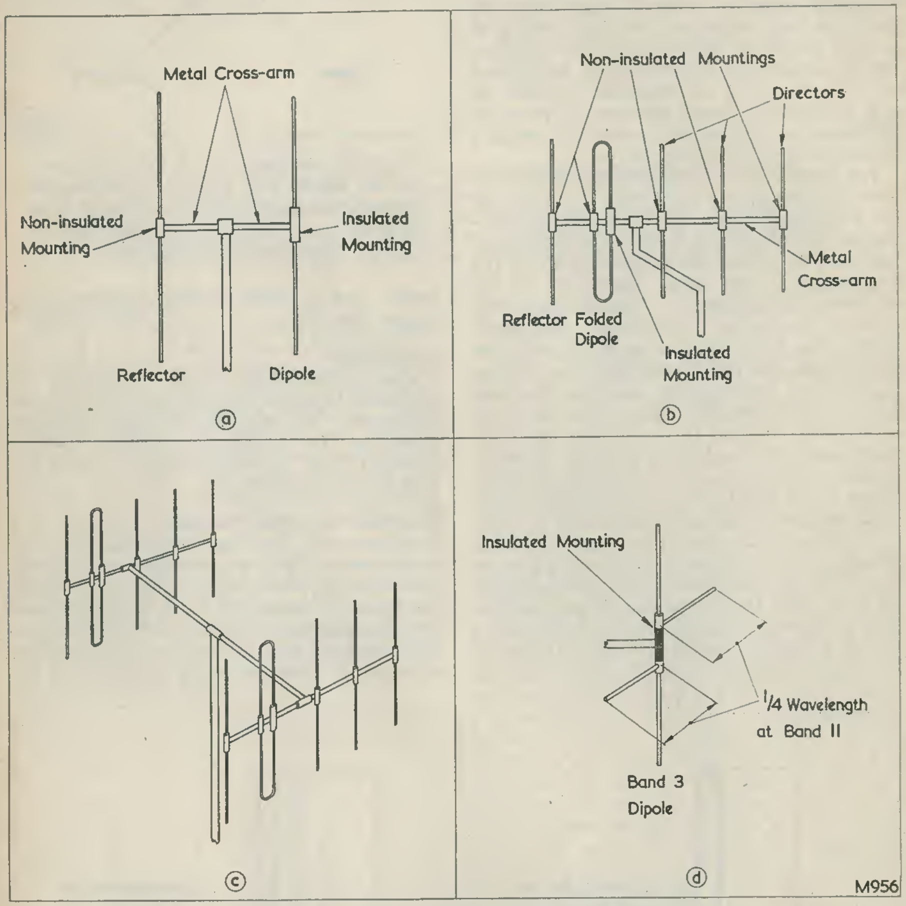


Fig. 241. (*a*) *A typical Band I "H" aerial*
(*b*) *A Band III aerial with three directors*
(*c*) *A broadside array*
(*d*) *A combined Band I vertical dipole and Band II horizontal dipole*

At Band III wavelengths element lengths are much shorter than at Band I, and it becomes possible to design aerials having a large number of parasitic elements which are still not excessively cumbersome or unwieldy.

Speaking in very general terms, reflectors in practical aerials are usually some 5 to 6% longer than the associated dipole. The director nearest to the dipole is usually some 4 to 5% shorter, further directors decreasing in length progressively. These figures are, however, very general: the design of a television aerial employing parasitic elements is a complex process in which the length, spacing and diameter of elements are all inter-related.

It is possible to employ two aerials, complete with parasitic elements, in a "broadside" array, as shown in Fig. 241 (*c*). The aerials are spaced by a half-wavelength and, for true "broadside" operation, the dipoles should be cross-connected such that the upper part of one dipole connects to the lower part of the other.

Sometimes, a means is provided for tilting a Band I or Band III aerial such that the directors are higher than the reflector. This allows optimum signal strength to be achieved when the incoming signal is downward-moving.

Combined Band I–Band III aerials are often employed, and designs vary considerably according to the manufacturer. A possible Band I–Band III aerial could employ a set of Band III elements with a Band I element at the rear, this functioning as a Band I dipole and as a Band III reflector. Alternatively, an "H" or "X" (to be discussed shortly) Band I aerial could appear after the Band III elements, the first Band I element—either a dipole or a director—functioning as a Band III reflector. Other combinations of Band I and Band III elements are feasible. An interesting combination of Band I and Band II aerials[3] is illustrated in Fig. 241 (*d*). In this diagram horizontal conductors are added at the centre of a conventional Band I dipole, causing a second horizontal dipole tuned to Band II to be effectively connected to the feeder. Such an arrangement can be used with combined television—f.m. receivers having a common aerial input circuit.

An alternative to the "H" aerial is the "X" aerial. In an aerial of this nature one-half of the "X" may consist of a dipole, and the other half of directors. Another variant is the "K" aerial, in which the vertical element may be the dipole and the two inclined members directors. "X" and "K" aerials are employed for Band I reception and offer an alternative to the conventional "H" aerial. Apart from any technical advantages such aerials may have over the "H" aerial, they have the mechanical advantage of deleting the cross-arm, thereby providing a lighter assembly.

Next Month

In next month's article we shall continue with our discussion of television aerials, carrying on to "indoor" aerials, and to feeders.

[3] Band II is employed for f.m. sound transmissions, and employs horizontal polarisation.

CAN ANYONE HELP?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

Jason F.M. Tuner.—E. Gale, 18 Tennal Grove, Birmingham 32, wishes to obtain details of modifications necessary to coils L_1, L_2 and L_3 of the fringe area model in order to cover the frequencies 115 to 130 Mc/s.

* * *

Hammarlund Super-Pro Receiver.—G. Preston, 31D Hill Road, Arborfield, Reading, Berks, requires a copy of the circuit or the manual.

* * *

McMurdo Silver "15-17" (1938/9).—L. A. Brown, 23 Oxford Avenue, Cleethorpes, Lincs, urgently requires the manual or alignment details and any relevant information.

* * *

MCR1 Receiver.—C. Robinson, 15 Lindley Street, Blackburn, Lancs, would like to obtain the circuit or manual of this receiver. Failing these, details of the valve line-up would be of great assistance.

* * *

Eddystone 358X Receiver.—P. G. Bell, 27 Churchill Avenue, Horsham, Sussex, would like to obtain circuitry of modifications to this receiver.

Communication Receiver Design.—J. Langford, 20 Eastlake Avenue, Parkstone, Dorset, would like to hire any copy of *The Short Wave Magazine* (since 1958) which has featured details of a home-constructed communications receiver.

* * *

Transistor Portable Receiver.—James M. Buchanan, Morningside Road, Annan, Dumfriesshire, is consiering the purchase of such a receiver, in kit form, and would be pleased to receive from readers any information on the sensitivity of such sets. The receiver would be required for use in the western Highlands of Scotland where signal strengths are very low.

* * *

420 Mc/s Articles.—G. Allcock, G3OVO, South End, Beck Hill, Tealby, Lincoln, requires the texts and circuits of the 420 Mc/s articles published in *QST*, May 1951, page 39, and June 1948, page 52.

* * *

R1471 Receiver.—I. G. Morgan, 21 Pontey Mount, Waterloo, Huddersfield, Yorks, wishes to obtain the circuit diagram, servicing data and details of any modifications readers may have made in order to improve performance.

Designing a High Impedance Transistorised Voltmeter

By S. SMITH

IDEALLY, A VOLTMETER SHOULD HAVE infinite impedence, so that it does not disturb the circuit being measured. This ideal is unattainable, but the high input impedance of thermionic valves (particularly "electrometer" valves) allows valve voltmeters to be designed with such high impedences that the resulting disturbance to the measured circuit is quite negligible.

Valves require a substantial power supply and are not very rugged, therefore a valve voltmeter is rather more delicate and inconvenient than one would like, as well as being too bulky and heavy to slip into the pocket for an outside servicing job.

Transistors are rugged, very small, and lend themselves very well to subminiature portable equipment, using small torch batteries as their power supply; but they have a low input impedance (1 to 2kΩ, compared with 1 to 10 MΩ for valves). In the circuit that follows, two transistors are given a very high input impedance by using 100% negative feedback, their very low output impedance under these conditions being used to drive a cheap meter (1mA full scale deflection, resistance 100Ω). Transistorised voltmeters have been described previously, but they usually require four transistors and a 100μA meter, this adding up to quite an expensive instrument.

Obtaining a High Input Impedance

100% negative feedback (by putting the load in the emitter circuit) gives a high input impedance, and a low output impedance, in the following manner.

In Fig. 2, v_b (voltage at the base) is approximately equal to v_e (voltage at the emitter) by "emitter follower" action: i.e., if the emitter voltage goes down (or up) there is a heavy increase (or decrease) in collector current, and hence current through "R", which restores the emitter voltage to its original value.

Since $v_e = v_b$ approximately

$i_c = \alpha'' i_b$ (where α'' is the transistors' grounded collector current amplification factor)

and $v_e = R\, i_c$

Then change in v_b = change in v_e = R × change in i_c = R × α'' × change in i_b

i.e. $\dfrac{\text{change in } v_b}{\text{change in } i_b}$ (= input resistance) $= R \times \alpha''$

Thus the input resistance is α'' times the emitter load.

If this transistor is the emitter load of another transistor, the input resistance of whole assembly will be $\alpha'' \times \alpha'' \times$ emitter load. In this way, vary large input impedances can be built up, because α'' is of the order of 20 to 100 (40 is a common value), and each additional transistor multiplies the input impedance by this factor.

The output impedance is low, because change in $i_c = g_m \times$ change in v_b (using g_m in the "mutual conductance" concept already familiar from valve practice)

$= g_m \times$ change in v_e (by "emitter follower" action)

Thus $\dfrac{\text{change in } v_e}{\text{change in } i_c}$ (=output impedance) $= \dfrac{1}{g_m}$

25Ω would be a common value.

Adding a Second Transistor

In Fig. 3, the emitter load is two resistances in parallel, one of 100Ω (the meter), and one of 10kΩ: the net load is thus 100Ω, the 10kΩ is 100 times larger and could take only 1% of the available current. If we arrange matters as shown, with a base voltage of about 4.5V, and a 4.5V battery opposing the current through the meter, no current will flow through the meter. Any change in base voltage, however, will cause current to flow through the meter, with its 100Ω resistance, rather than the 10kΩ resistance. The input impedance of this arrangement is $\alpha'' \times 100\Omega$, i.e., about 4kΩ. This is not enough: we therefore use the circuit of Fig. 3 as the emitter load of another transistor, and obtain the circuit of Fig. 4.

The base of the second transistor (TR_1 in Fig. 4) is not connected into circuit, so the transistor passes its normal "leakage current", which is usually between 50 and 200μA. This current has to produce about 4.5V across the emitter load "r" to satisfy the second transistor. Thus, "r" is in the

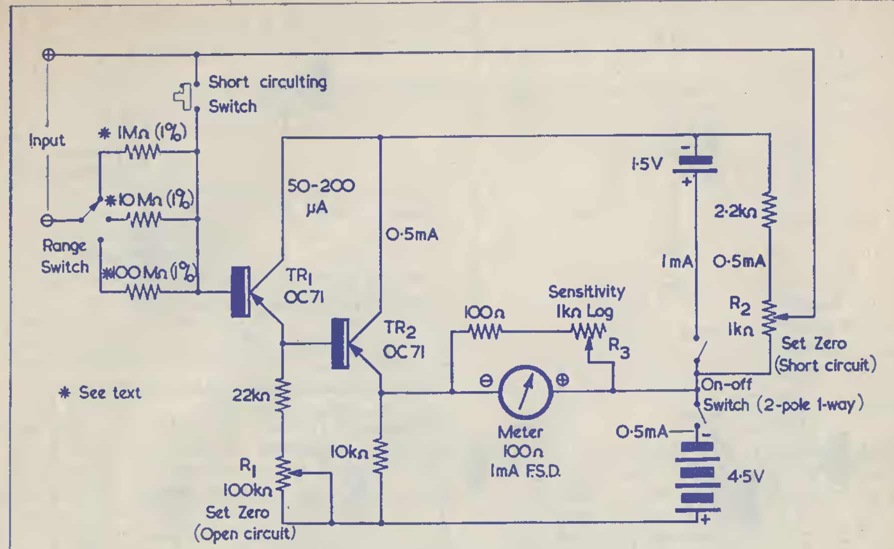


FIG. 1. The circuit of the complete Voltmeter.

range 90kΩ to 22kΩ. We therefore make "r" 22kΩ+100kΩ variable in series. We have seen that the input resistance of the circuit of Fig. 3 is about 4kΩ, so connecting 22-90kΩ across it in parallel does not affect it a great deal. The input resistance of the whole circuit of Fig. 4 is now $\alpha'' \times$ 4kΩ. At low collector currents, like 50-200μA, α'' is lower than usual; 25 is fairly typical. So the nett input resistance is 25×4kΩ=100kΩ approximately.

100mV across a 1mA meter of resistance 100Ω gives full scale deflection. So 100mV input to the circuit in Fig. 4 gives full scale deflection. We have, then, 100mV input into a resistance of 100kΩ, i.e., I megohm per volt input, which is of the same order as that of a valve voltmeter.

The base of the input transistor, TR_1, is at 4.5V, plus a hundred millivolts or so, necessary to cause the second transistor to pass about 0.5mA and thereby cause the meter to give a zero reading. The input is therefore connected to the base of TR_1 and to a point in the circuit that is at an equal voltage; this giving rise to the arrangement shown in Fig. 5. Here we have added a 1.5V cell, to give a working potential of 1.5V between the collector and emitter of each transistor; and we use the same cell as the source of the 100-300mV above the emitter potential required to bring the other side of the input up to the potential of the base of TR_1. The resistances employed must not be of the same order as the circuit's input resistance or sensitivity to low voltages will suffer, so a value of 1kΩ (=1% of the input resistance) was chosen.

The Complete Instrument

It is likely that the circuit parameters will be such that full scale deflection occurs at an input voltage that is not a round number: indeed it would be a sheer fluke if it were, say, exactly 100mV or exactly 200mV. For this reason, we must put a variable resistor in parallel with the meter to decrease the sensitivity of the circuit to a satisfactory round number. If the parallel resistance were the same as the meter's resistance, it could cause sensitivity to be reduced by as much as a half, if necessary. Thus if, say, the sensitivity were 143mV for full scale deflection, operation of the variable resistor could change it to 150mV, or 200mV, or 250mV, as required. In Fig. 1, which shows the circuit of the complete voltmeter, the variable resistor appears as R_3, the 100Ω fixed resistor being included to restrict its range.

In Fig. 1 high-value resistors have been added in series with the input to change the range of the instrument: values of 1MΩ to 100MΩ are shown. These are nominal values, based on an input resistance of 100kΩ. In a practical instrument, the input resistance can differ from 100kΩ quite appreciably; it varies, for example, with the setting of the sensitivity control, R_3. The correct values of the high-value

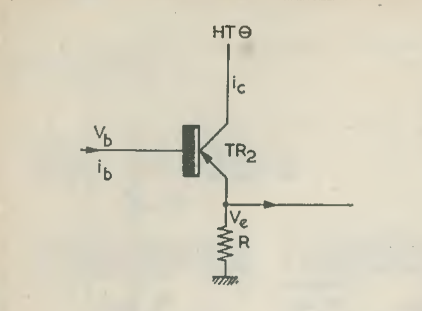


FIG.2

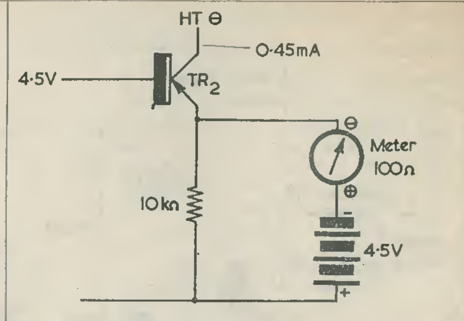


FIG.3

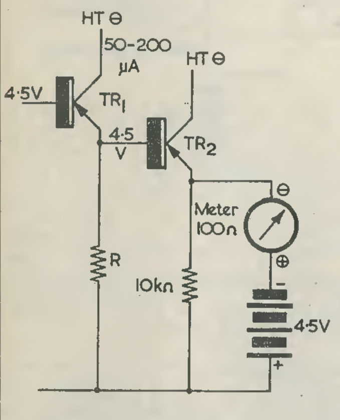


FIG.4

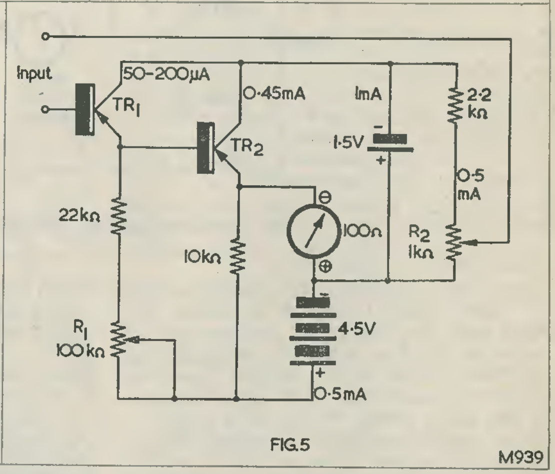


FIG.5

resistances are found by experiment in the following manner.

When the instrument has been set up, as detailed below, a source of known voltage equal to a volt or less is applied between the positive input terminal and the base of TR_1 via a 1MΩ 1% resistor. The sensitivity control R_3 is then adjusted. If input sensitivity is of the order of 100mV or better, it should be possible to obtain a reading on the meter which corresponds to 1 volt full scale deflection. If sensitivity is worse than 100mV then R_3 should be adjusted so that full scale deflection corresponds to the next convenient round number, say, 1.5 or 2 volts. The full scale reading obtained at this stage will then be multiplied by 10 when a 10MΩ series resistor is employed and by 100 when a 100MΩ series resistor is employed. Thus, if initial experiments with the 1MΩ resistor result in an f.s.d. figure of 1.5 volts being chosen, the three ranges switched in by the range switch of Fig. 1 would be 0-1.5 volts, 0-15 volts and 0-150 volts. Values of series resistor other than those shown in Fig. 1 could, of course, be employed to obtain different multiplying factors.

A simple method of obtaining the source of potential just mentioned would consist of connecting a potentiometer having a value between 2 and 10kΩ across a single 1.5 volt cell, as shown in Fig. 6. An external voltmeter is connected between the slider of the potentiometer and one end of the cell in order to monitor the potential tapped off. By careful adjustment of the potentiometer it should be possible to obtain a potential equal to a round number, thus simplifying the procedure of initially selecting the figure for f.s.d.

Setting Up

(*i*) With the input terminals open-circuited, adjust R_1 until the meter reads zero. This adjusts the emitter potential of TR_1, caused by the TR_1 leakage current, to the value required to bring TR_2 emitter potential exactly to the 4.5V battery's potential.

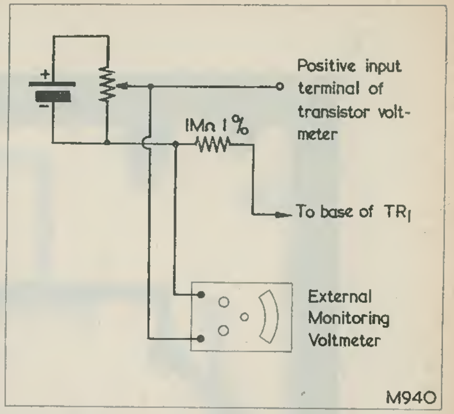
(*ii*) With the input terminals short-circuited, adjust R_2 until the meter reads zero again. This brings both of the input terminals to the same potential.

(*iii*) Set the sensitivity control and choose the high-value series resistances as described above.

Operation

Use of the instrument is straightforward. It can be extended to a.c. measurements by using a diode probe in the usual way. For measuring very high voltage, it is recommended that a high resistance potentiometer be used to precede the instrument and reduce the voltage by a known factor, because very high value resistors tend to be unreliable. To measure, say, 1000V, a series resistor of 1000MΩ may be needed, and resistors of such high value are not reliable: it would be better to connect 100MΩ+10MΩ across the supply and to connect the instrument on its highest range across the 10MΩ resistor, thus measuring one eleventh of the input voltage.

Transistors are sensitive to heat, including the heat generated by their own power dissipation. So, unlike a valve voltmeter, drift is a problem with this instrument. For greatest accuracy, R_1 and R_2 should be adjusted before every measurement as detailed in setting-up steps 1 and 2. It will be found in practice, however, that R_1 and R_2 rarely need adjustment more often than once at the beginning of each day.



A Printed Circuit Transistor Pre-amplifier

by G. N. DALE

THE CONVENIENCE OF HAVING A CONTROL unit separated from the main amplifier is a well established principle in high fidelity audio work, although a certain number of composite pre-amp/amplifier units are commercially available in the middle price range. While thermionic

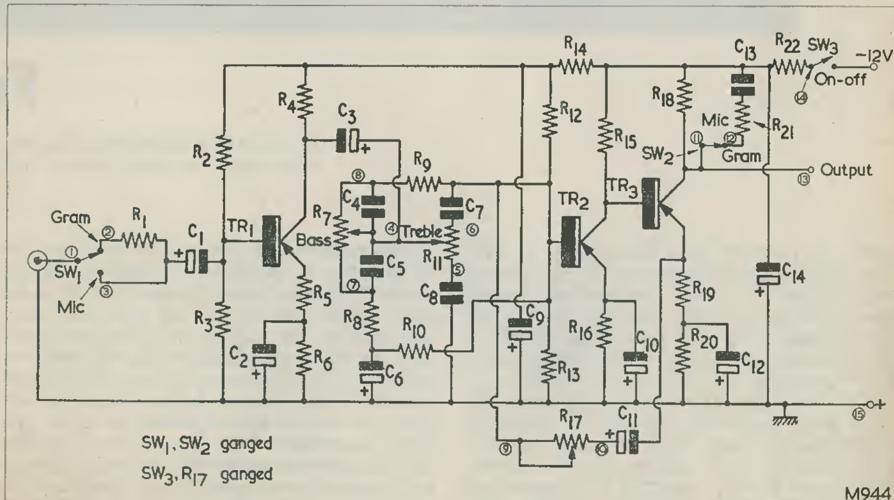


Fig. 1. The theoretical circuit of the pre-amplifier. The circled numbers correspond to the wired connections illustrated in Fig. 3.

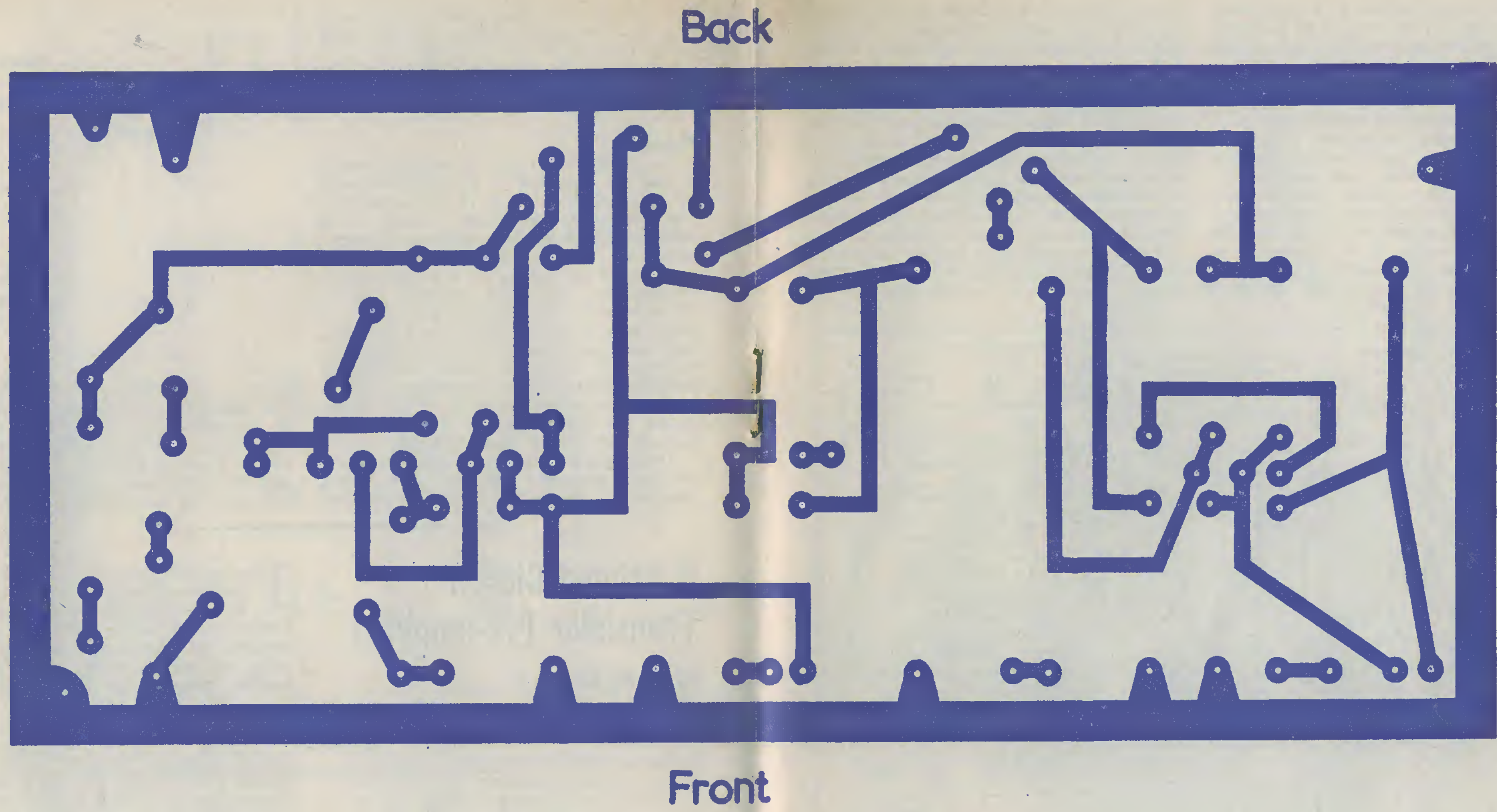


Fig. 2. The printed circuit layout. This diagram has been reproduced here on a 1:1 basis and may therefore be traced direct. The copper side is uppermost

valves have been used exclusively in pre-amplifier design, the constructor has always been faced with the problem of finding the ideal layout and making the choice of components which kept noise levels to the absolute minimum. The arrangement and screening of connecting leads was critical and the high input impedance of valve grids called for the use of matching transformers when reproducing moving coil pickups and microphones, adding still more to the problem of screening. The need for high stability resistors for noise limiting added further to the expense of the unit.

Dismayed, no doubt by the poor quality of so many of the modern portable receivers, where transistors are operated too close to their limits, the enthusiast could at first be excused for saying that the transistor had no place in serious audio design. In a pre-amplifier, however, the source voltages are far from minute and a large overall gain is not always required to drive the main amplifier. This allows for a circuit in which transistors can be used at relatively low operating currents and feedback is employed to keep distortion to the absolute minimum.

The present design is based on a circuit published some time ago in *Transistors for The Experimenter* (published by Mullard Ltd.). The low input impedance (5,000Ω) is one of its most useful features, making the unit very suitable for use in conjunction with moving-coil microphones or pickups, the maximum input voltage being only 30mV. The circuit is capable of a voltage gain of 220, and a current gain of 400, sufficient to drive a valve main amplifier. The tone controls should give more than 10dB of boost and cut at 50 c/s and 12 kc/s. At maximum gain 20dB of feedback is obtained, so that distortion is negligible.

All three transistors have a grounded emitter circuit. Although in this configuration the maximum operating frequency is less than that for the grounded base arrangement, there is no effective limitation at audio levels and one has the advantage of a comparatively high current gain. This is very desirable in the first stage to allow for the attenuation which takes place in the tone control network (R_7, R_{11}, etc.).

Full use is made of negative feedback in order to reduce distortion and improve the frequency response. As feedback which is applied over several stages may result in phase shift at upper frequencies, it is incorporated in the present design at two points. The emitter resistor R_5 is unbypassed producing some a.c. negative feedback, and the loop formed by R_{17}, C_{11} applies voltage taken from the emitter resistance of TR_3 to the base of TR_2. R_{17} being variable, the feedback is employed here to control gain over the second and third stages.

The circuit can be power or battery driven, although the latter is to be preferred so as to avoid hum and microphony, particularly as the current drain is only 4mA. An excellent source of voltage is a combination of a grid bias (9V) and flat pocket torch battery (4.5V) connected in series so that the tappings of the grid bias battery can be used to adjust for ageing.

C_4 and C_5 are not included in the printed circuit but are mounted behind the potentiometer R_7. There is no significance in the fact that some of the 100μF condensers are shown physically larger than others. This results from the fact that available components were used wherever possible for the present unit. Values for R_1, R_{21} and C_{13} will depend on the type of equipment being used with the pre-amplifier, R_1 giving attenuation and the network R_{21}, C_{13}, a constant treble cut required with some types of pickup. To make the unit more versatile a potentiometer may be substituted for R_1, connecting the ends to C_1 and "earth" respectively and the slider to the

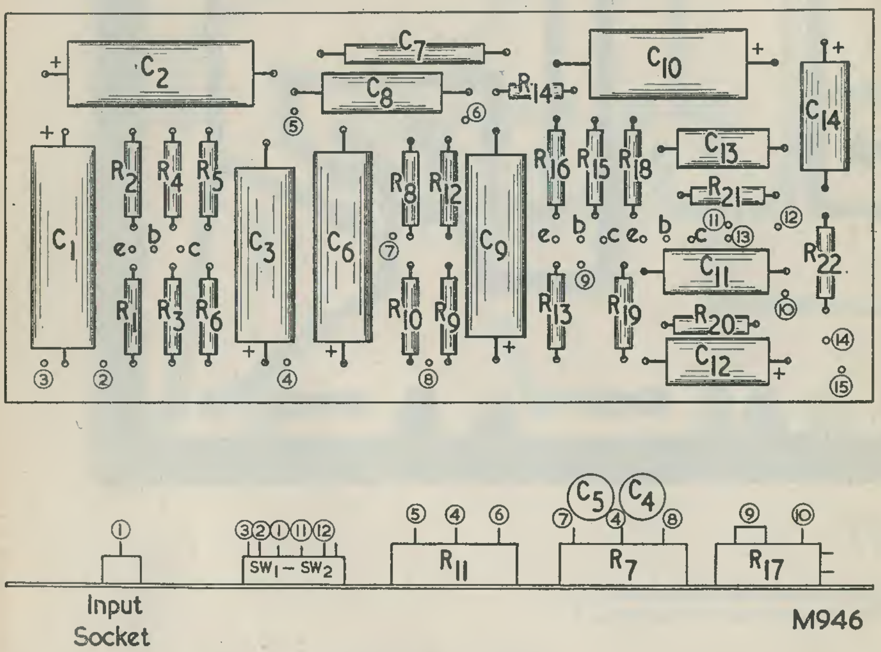


Fig. 3. Component layout as viewed from the top of the board. Wired connections are shown by pairs of circled numbers. On switches SW_1, SW_2, contacts 2 and 12 are connected to their respective sliders in the "Gram" position. For clarity, the on/off switch of R_{17} is omitted. One contact of this switch should be taken to connection 14 and the other to the negative battery lead. Connection 13 is that of the output and connection 15 should be taken to the positive battery lead

No special printed circuit components are required in this design. Switches and potentiometers are conventional and wires are taken from these to appropriate connections on the printed circuit; this also results in a smaller board and more compact overall size. The wired connections are shown by the ringed numbers in Fig. 3.

input socket. A value of 100kΩ has been used successfully, but care should be exercised in using this as an impedance matching device, if distortion is to be kept to a minimum.[1]

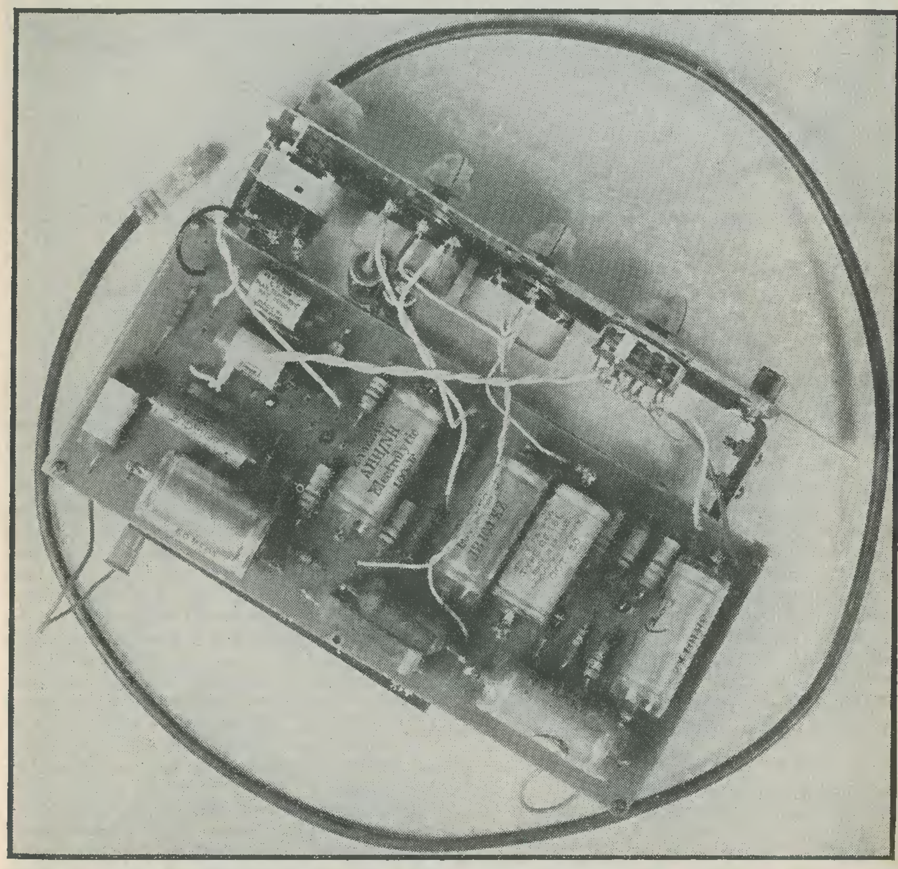
[1] Recommended values for R_1, R_{21} and C_{13}, for use with the Goldring Type 500 pick-up, are given in the components list.

The printed circuit may be made by any of the methods available to the home constructor. Fig. 2 is a "positive" of the circuit in which the black areas are conductors. Do not forget when comparing it with the top layout (Fig. 3) that the circuit as it appears here is the mirror image of the way it will look when viewed *through* the printed board.

Kits of materials for producing the etched circuit are available commercially, but the constructor who is beyond the stage of experimenting with this method and

paint (Belco is to be recommended); an aqueous solution of ferric chloride, about 20%; a flat dish or tray (porcelain, enamelled steel, or plastic) large enough to hold the largest board; an artist's small paint brush and a 1 or 2in paint brush.

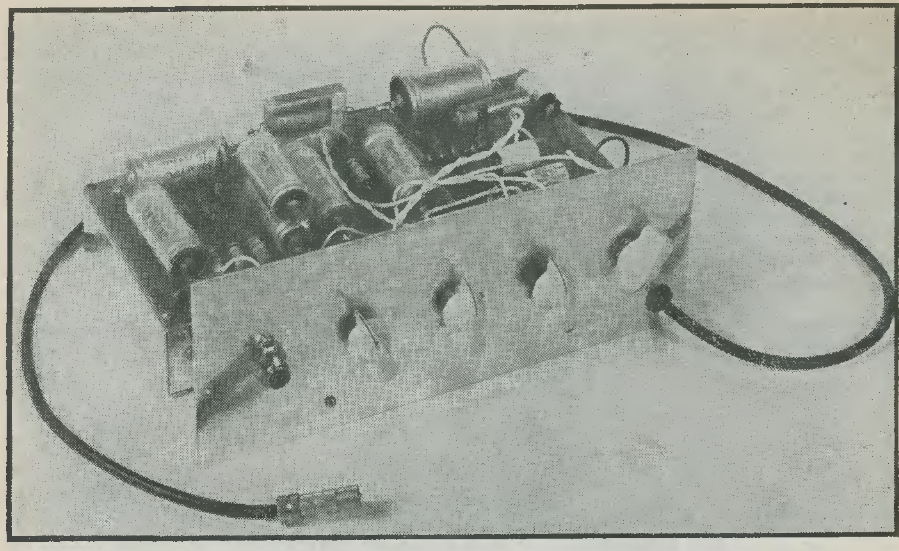
It is important to begin by thoroughly degreasing the copper surface so that good adhesion between it and the resist will result. The best method is to scrub with wire wool or a nylon dish cleaner and domestic scouring powder. After tracing the outlines of the circuit on to the copper,



Top view of the pre-amplifier showing the wiring between the printed board and the control panel components

plans to embark on a programme of several printed circuit units, will save money by obtaining the necessary items in quantity. The following will be required: Some copper-clad phenolic laminate; a suitable acid "resist" in the form of an oil or cellulose

the "conductors" are filled in by painting between the lines. When the resist is dry, the remaining copper is etched away in the ferric chloride solution. Etching progresses more rapidly if the solution is warm and may also be assisted by light brushing



Front view of the pre-amplifier. It will be noted that, in the prototype, C_3 is made up of two condensers in parallel. In practice, a single component can be employed here

over the copper surface while immersed. The paint must then be removed with a suitable solvent from the conductors and the board thoroughly cleaned so that traces of paint do not prevent good soldered connections from being made.

The laminate usually has a tendency to warp, with the copper on the concave side. This is flattened again when screwed down to the chassis and is unlikely to result in any damage to the foil above. However, care should be taken to see that the board is held reasonably flat when soldering components to it, as subsequent forcible straightening may break the connection or pull part of the copper conductor away.[2]

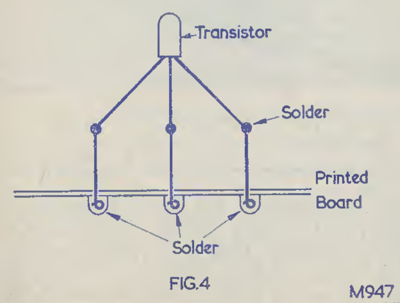


FIG.4

After making the board, holes for component connections should be drilled out with a 1/16th or 5/64th bit. If the condensers being used have tag terminals rather than wire ends, a short length of wire must be soldered to the tag for connection to the board. None of the components used are large enough to warrant additional strapping to the chassis. Transistors are best connected in the following way (see Fig. 4): take three short pieces of 24 s.w.g. wire, about ¾in in length; form small loops at one end, pass the straight ends up through the board and solder the loops to the conductors; the top of each wire may now be bent over about $\frac{1}{16}$in and a "blob" of solder dropped on each wire. Remember always to hold the transistor connections with the pliers in order to provide a heat shunt while soldering.

The controls on the front panel are in the following order: Belling-Lee coaxial input socket, input selector switch, treble lift and cut, base lift and cut, gain plus on/off switch. Note that a d.c. blocking condenser is not shown in the output circuit. A 0.1μF paper condenser may be required in series with the output depending on the first stage of the main amplifier. Attention should also be paid to the correct polarity of electrolytic condensers in the circuit.

The chassis is of simple construction, consisting of a shallow tray with flanges to which the printed board is held down by self-tapping screws at five points. Principal dimensions may be taken from Figs. 2 and 3 as these are reproduced to actual scale. The flanges should not be more than ¼in wide and capable of making good contact with the "earth" conductor around the edges of the printed board. The front panel is a plain sheet of aluminium, bolted to the front of the chassis by means of a bracket at ⅜in from each end. The whole unit may be mounted into a cabinet by screwing at the edges of the front panel (holes not shown).

[2] The preparation of printed circuits was fully described in "Do-It-Yourself Printed Circuit Boards" by Squadron Leader S. W. Sarll, A.M.(Brit.), I.R.E., *The Radio Constructor*, November 1959.

Components List

Transistors

TR_1, TR_2, TR_3 — OC71

Switches

SW_1, 2. 2-pole, 2-way rotary.

Resistors (All 5% unless otherwise indicated)

- R_1 (see text and note 1)
- R_2 39kΩ
- R_3 10kΩ
- R_4 27kΩ
- R_5 100Ω
- R_6 6.8kΩ
- R_8 1kΩ
- R_9 10kΩ
- R_{10} 10kΩ (10%)
- R_{12} 15kΩ
- R_{13} 4.7kΩ
- R_{14} 470Ω (10%)
- R_{15} 15kΩ
- R_{16} 5.6kΩ
- R_{18} 2.7kΩ
- R_{19} 100Ω
- R_{20} 1.5kΩ
- R_{21} (see text and Note 1)
- R_{22} 220Ω (10%)

Potentiometers

- R_7, R_{11} 100kΩ
- R_{17} 25kΩ (with on/off switch)

Condensers (All electrolytic condensers 6w.v. unless otherwise indicated)

- C_1 100μF
- C_2 100μF
- C_3 30μF
- C_4 0.05μF (10%) paper
- C_5 0.5μF (10%) paper
- C_6 100μF
- C_7 8000pF (10%) silver mica
- C_8 0.07μF (see Note 2)
- C_9 100μF 12 w.v.
- C_{10} 50μF
- C_{11} 100μF
- C_{12} 100μF
- C_{13} (see text and Note 1)
- C_{14} 100μF 12 w.v.

Note 1. The following values are suitable for use with the Goldring type 500 pickup. R_1=3.3kΩ, R_{21}=820Ω, C_{13}=0.5μF.

Note 2. C_8 may be made up with a 0.5μF and a 0.2μF condenser in parallel.

NEW ELECTROLUMINESCENT DISCOVERIES

New discoveries have brought the ndustrial and equipment lighting of the future—electroluminescence—one step nearer reality.

This lighting illuminates whole metal sheets by the use of phosphorus, which lights up when an electric current is passed through it. No filaments or elements are needed.

Dr. Peter W. Ranby (Chief Chemist at the Lighting Laboratories of Thorn Electrical Industries Ltd.) and his research group, have developed a method that increases the brilliance of the plates more than three times.

This, says Dr. Ranby, gives Britain European leadership in the electroluminescent field and equal footing with the United States.

Some of the new plates were seen at the Tenth Electrical Engineers Exhibition at Earls Court in March, on the stand of a Thorn subsidiary, Atlas Lighting Ltd.

Hitherto the brilliance at 240 volts and 50 cycles was 1 foot-lambert. The new developments have raised this to 4 foot-lamberts at 2,000 cycles. The increased brilliance is due to general improvements in processing and the use of new enamels.

As far as it is known, this is the only British company developing the "ceramic on metal" type of electroluminescent product with a lamp built upon a steel sheet which forms the back electrode. The phosphorus is embodied in a vitreous enamel, fired at high temperatures. The lamp is completed with a conducting transparent layer of tin oxide to form the second electrode, and a protective clear overglaze.

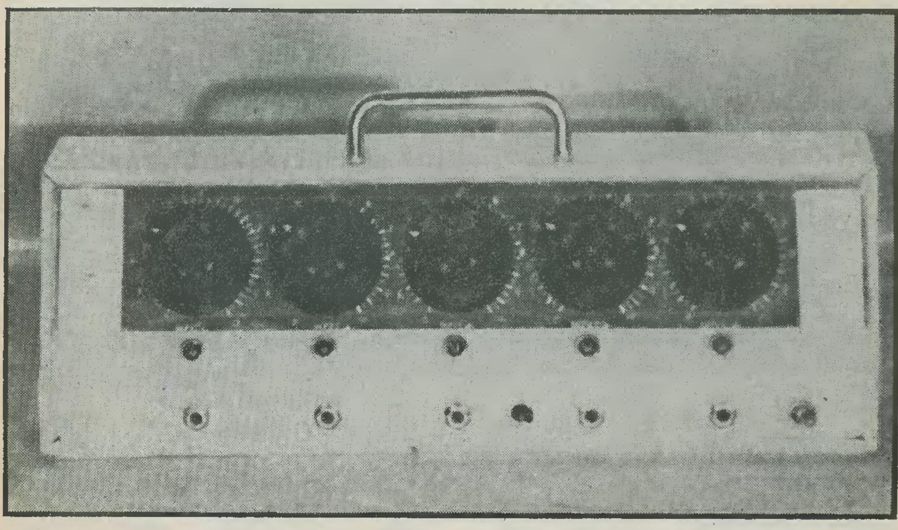
It is claimed that, for ceramic lamps, they are more robust and versatile than the "organic on glass" lamps. The latter consist of a glass sheet on which a transparent conducting film of tin oxide is deposited, followed by the phosphorescent layer in an organic resin binder. The condenser is completed by a second electrode of evaporated metal and the assembly sealed with paraffin wax to exclude moisture. This type of lamp is supplied as cabin signs for many aircraft, including Comets and Caravelles.

For instance: luminous telephone dials, in which an electroluminescent strip is placed behind the dial and current consumption will be a matter of a few pence a year.

These lamps are suitable for aircraft instruments, car instruments panels and radio tuning dials; luminous clock faces and map readers are already in production.

Plans for the future include the use of electroluminescent road signs for the new motorways. Once installed, running costs will be negligible.

Design for a Stereo/Mono



by P. R. TRAVERS

Microphone Mixer Unit

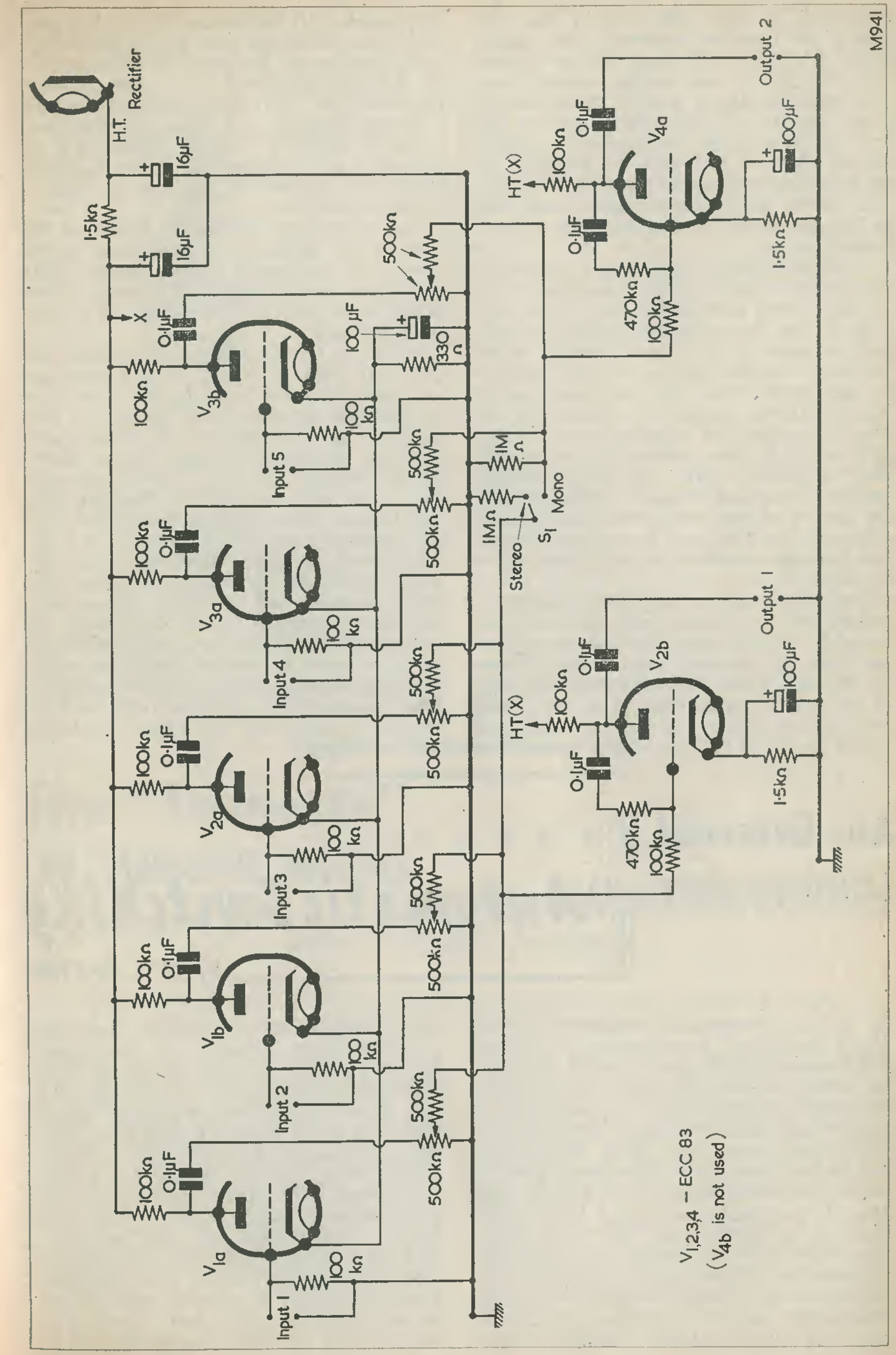
SINCE THE WRITER'S ARTICLE ON DESIGNING a microphone mixer unit was published in 1959* a requirement has arisen for a stereophonic mixer unit. In making stereo recordings of choral and orchestral works, or of theatrical productions, it is often essential to use more than one microphone in each channel. The first solution seemed to be to build two independent mixer units but, having already built a five-channel mixer with its own power supply, I was loath to discard it.

After a little thought it was found possible to convert the five-channel unit to a comprehensive mixer unit with the following specification.

1. To be a stereophonic mixer having three inputs for the left channel and two for the right.
2. Separate outputs to be available for left and right channels.
3. To be available also as a five channel monophonic mixer.
4. Two identical outputs to be available, each fed with the same mono signal but each completely independent of the other. This allows two recorders or a recorder and a separate amplifier to be fed with the identical signal.
5. The unit to be self-powered.
6. Figures for hum, noise and crosstalk to be kept to a minimum.
7. There should be immediate visual indication of the channels in use.

The circuit of the unit is shown in the accompanying diagram. It will be seen that each input channel is fed to a separate triode voltage amplifying stage. The signal at each triode anode is fed via a 0.1μF condenser to a 500kΩ gain control. The 500kΩ resistors connected to the gain control sliders prevent interaction between the channels; without those resistors the volume level in one channel would be

* Designing An Electronic Mixer Unit", by P. R. Travers, *The Radio Constructor*, July, 1959



influenced by any alteration in the gain setting of another channel. The signals from the three left hand inputs (Inputs 1–3) are fed to the output triode $V_{2(b)}$. The amplified signal is then fed to Output 1 via the 0.1 μF condenser. As the full gain of the stage is not required a portion of the signal is fed back to the grid via the 0.1μF condenser and the 470kΩ resistor. This serves to improve quality and also to keep hum and noise to negligible proportions.

A similar output stage ($V_{4(a)}$) is provided for Inputs 4 & 5, which together form the right hand channel for the stereo pair.

S_1 is the Stereo/Mono function switch, and is shown in the Stereo position in the diagram. In this position a 1MΩ resistor is connected from the combined inputs of each stereo channel to chassis. In the Mono position the outputs from all five gain controls are connected in parallel with a single 1MΩ resistor connected between them and chassis. In this position the combined signal is fed to both output stages in parallel, and thus two identical but quite independent output channels are available.

The gain controls are 500kΩ: potentiometers with a single pole switch. The switch is wired so that a pilot light is switched on when the control is operated. Power for this light comes from the heater winding of the mains transformer. The pilot lights are situated below the gain controls and above the input sockets. Thus, even when the equipment is operated in the half darkness that exists backstage in a theatre, immediate visual indication is given of the channels in use. A refinement is to use different coloured pilot lights for each stereo channel.

Power supplies are quite conventional, a valve full-wave rectifier being used to provide h.t. If desired, a saving in space could be achieved by the use of modern miniature rectifiers.

The photograph shows the layout of the unit. As it is invariably used close to the associated equipment, short output leads are fitted and cathode follower output stages were discarded in favour of triodes with feedback.

Within a few days of its completion the unit was used to record an extensive out of doors ceremony, and at the same time to feed an elaborate P.A. system. Three microphones were required for the ceremony with an additional commentator's microphone. It has also been used to record a large orchestral concert, a Passion Play with actors, choir, soloists and organ, and a "straight" play, all in stereo.

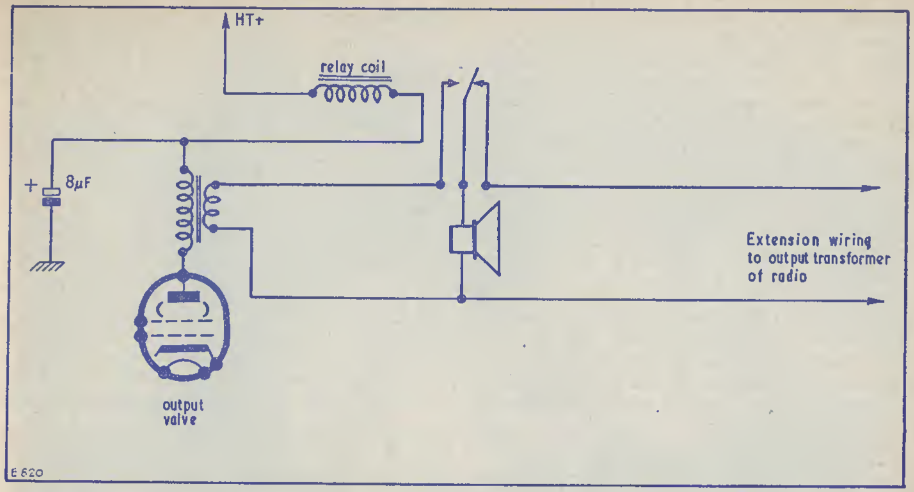
Crosstalk is better than 60db. at 1kc between any two channels and better than 90dB. between left and right channels in the Stereo position. Hum and noise are inaudible with no inputs jacks inserted and all gain controls set at maximum (self-earthing sockets are used). With microphone plugs inserted, hum and noise vary with the length of cable and the care with which it is positioned.

An External Loudspeaker *with* Automatic Switching

by M. J. DUNN

Many people like to listen to sound broadcast programmes in rooms remote from that in which the radio set is kept. Normally this involves the purchase and installation of an extension speaker and cabinet—usually a boxy little affair placed on a shelf. Both the expense, and finding space for the extension speaker, can be avoided by making use of an existing item of equipment containing a loudspeaker (such as a radiogram). The latter may, also, offer the advantages of a superior loudspeaker and a larger cabinet. The circuit to be described shows how the loudspeaker in such equipment may be employed as an extension speaker without the complications of manual switching, a simple relay causing the loudspeaker to be switched to the extension wiring whenever the equipment is switched off.

It is most important to ensure that the equipment whose speaker is used as an extension loudspeaker has a chassis which is isolated from the a.c. supply by a mains transformer. The circuit must not be used with equipment having an a.c./d.c. power supply. The reason for this warning is that, if it is not followed, the extension speaker wiring may be at mains potential. Suitable isolated equipment will normally be provided by radiograms, some of the older model television receivers, and the larger table model radios.



The switching circuit accompanies this article. The coil of a relay having changeover contacts is connected in series with the output transformer of the apparatus which houses the loudspeaker. The contacts are arranged so that when they are at rest, the loudspeaker is connected to the extension wiring. When it is required to use the apparatus itself the latter is switched on. As soon as the output valve has warmed up current is drawn through the coil of the relay, whose contacts then switch the speech coil to the secondary of its own output transformer. From a constructional point of view the entire modification is conveniently centred round one (usually) accessible component—the output transformer. An 8μF electrolytic condenser is included in the circuit to prevent the relay coil taking part in the a.c. load of the valve.

The "Twinette"

TWO TRANSISTOR RECEIVER

A SIMPLE EASY-TO-BUILD LOCAL STATION SET

Described by R. J. CABORN

This article gives full details of a simple two-transistor receiver capable of being built both by the beginner and by the more experienced constructor

There is always a demand amongst constructors for simple receivers which, whilst taking advantage of all the facilities offered by transistors, are still relatively inexpensive and easy to build. The "Twinette" meets this demand. It employs only two transistors, but these are used in a circuit which offers a very high degree of gain, such gain being realised by operating the first transistor in a reflex circuit wherein it carries out the double function of r.f. and a.f. amplifier, and by employing reaction. The latter further allows a satisfactory level of selectivity to be achieved. The output transistor feeds into a 7in x 4in elliptical speaker, a speaker of this size being specified in order to take full advantage of the output power available. As may be seen from the photographs which accompany this article, the chassis dimensions are such that the speaker fits snugly into the component layout.

The "Twinette" is a local station receiver, and it employs separate ferrite slab aerials for Medium and Long wave reception. Facilities are provided for connecting a short external aerial in poor reception areas. The receiver is powered by a single battery.

Circuit

The circuit of the "Twinette" appears in Fig. 1. At the left hand side of this diagram are the two ferrite slab aerials. Windings L_1 L_2 and L_3 appear on the Medium wave ferrite slab aerial, and windings L_4, L_5 and L_6 appear on the Long wave ferrite slab aerial. These windings are switched in and out of circuit by the three switches connected to their upper terminals. These three switches are combined with the on-off switch in a 4-pole 3-way unit providing "Off", "M.W.", and "L.W.". The numbers appended to the switch contacts in Fig. 1 correspond to those employed in the wiring layout diagrams which follow. Of the sets of windings on the ferrite slab aerials, L_1 and L_4 are tuned windings, L_2 and L_5 are coupling windings which provide a low impedance match into the base circuit of transistor TR_1 and L_3 and L_6 are reaction windings. When an external aerial is employed this is connected, via C_7, to the tuned windings.

The low impedance r.f. signal from L_2 or L_5 (according to whether "M.W." or "L.W." is selected by the switch) is fed directly to the base of transistor TR_1 and, *via* condenser C_2, to its emitter. C_2 has a low reactance at r.f., with the result that almost all the r.f. signal from the ferrite slab aerial appears across the base and emitter of TR_1. TR_1 functions as an r.f. amplifier, and the amplified signal appears at its collector, the r.f. choke L_7 functioning as a collector r.f. load. The amplified r.f. is then fed to the detector D_1, *via* condenser C_4. The r.f. choke L_8 provides a d.c. circuit for the detector, and a detected signal appears

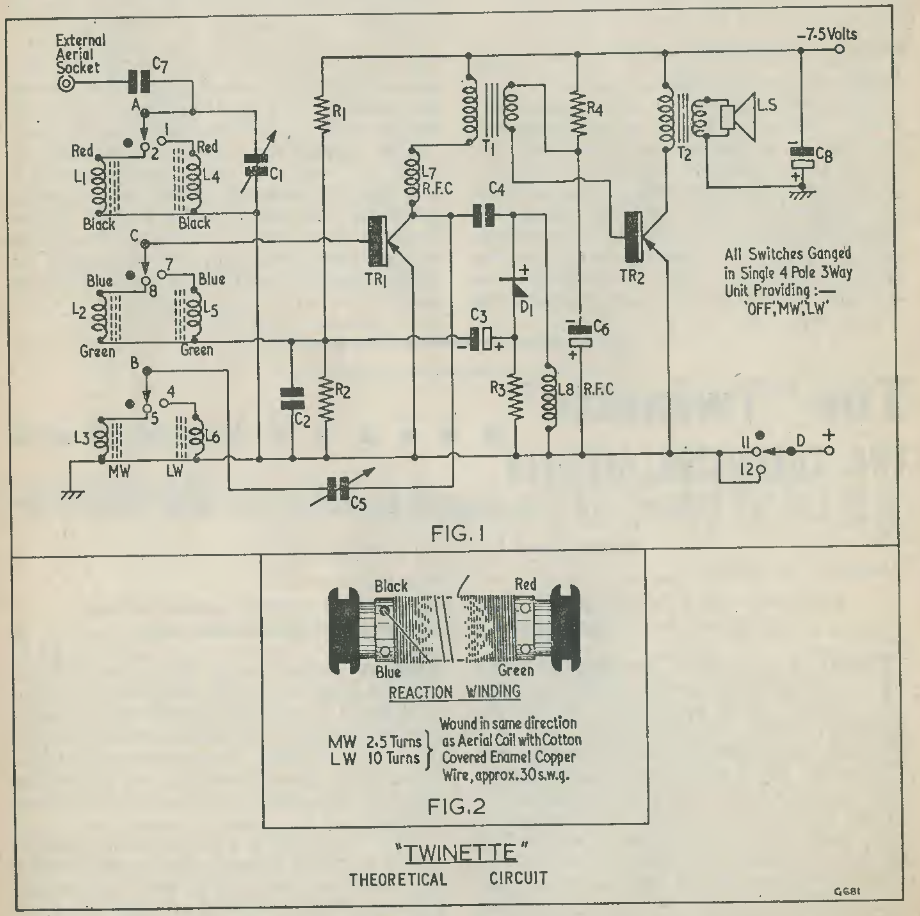
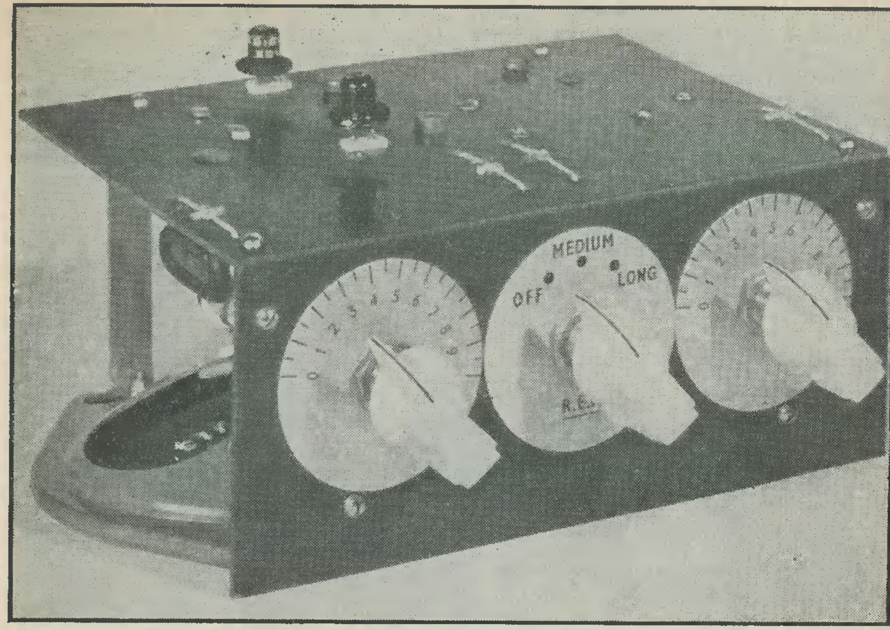


Fig. 1. The circuit of the "Twinette"
Fig. 2. How the reaction windings are added to the ferrite slab aerials



Front view of the completed "Twinette" Transistor Receiver

across R_3. This signal is passed, *via* C_3, to C_2 and the lower terminals of L_2 and L_5. C_2 now carries out the secondary function of bypassing the r.f. component in the detected signal to chassis, its reactance at r.f. being sufficiently high to prevent any undue loss of detected audio signal. The detected audio signal is next applied, by way of L_2 or L_5 (according to which is selected by the switch) back to the base of TR_1. This time TR_1 functions as an a.f. amplifier, the amplified a.f. signal appearing across the primary of transformer T_1. Bias for TR_1 is provided by R_1 and R_2.

The secondary of T_1 couples into the base and emitter circuit of the output transistor TR_2, the emitter coupling being made *via* C_6. Resistor R_4 biases TR_2, causing it to operate at the desired point on its characteristic. The collector of TR_2 then feeds into the primary of the speaker transformer T_2. Condenser C_8, connected across the supply, ensures the existence of a low impedance between the positive and negative supply rails, thereby enabling the receiver to be used even when the internal resistance of the battery reaches a high value due to ageing.

Construction

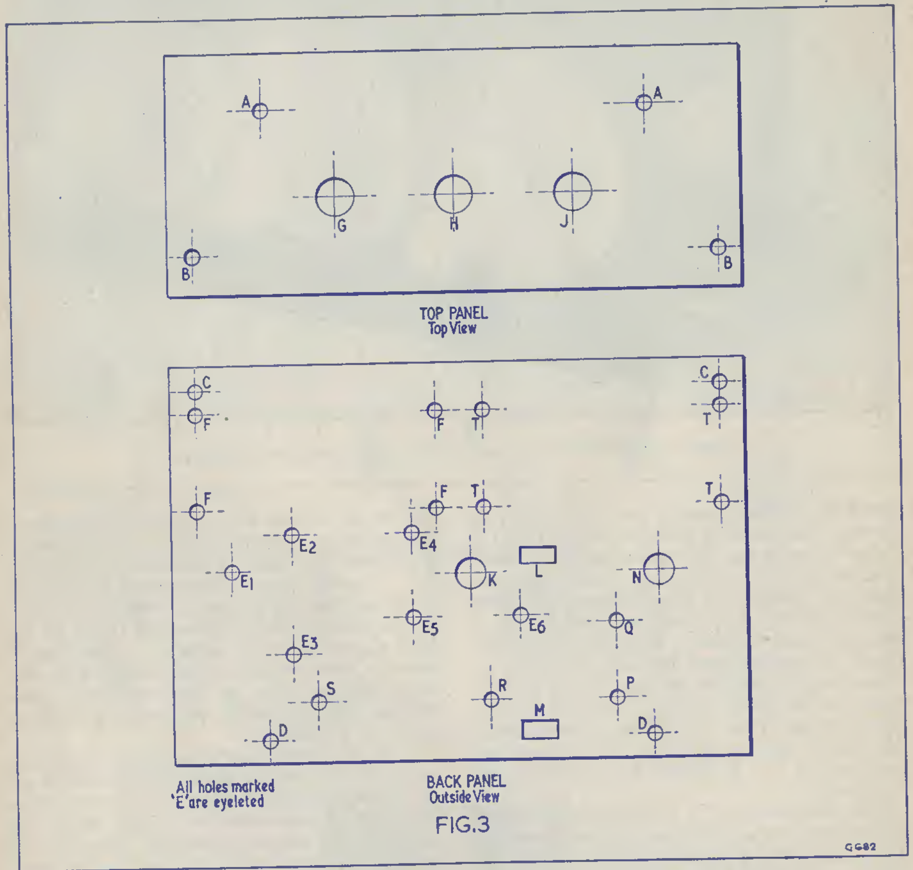
Construction proceeds in the following manner. The first steps are illustrated in Fig. 4. It will be found helpful, throughout construction, to refer to Fig. 3, which illustrates hole layout in the top and back panels.

1. Wind 2½ turns of enamelled and silk or rayon covered wire (approximately 30 s.w.g.) on the Medium wave slab aerial (FS_3) in the same direction as the aerial coil. See Figs. 2 and 5. Best results are obtained with the coupling coil close to the black and blue eyelets. Connect additional winding to black eyelet, as illustrated.
2. Wind 10 turns of enamelled and silk or rayon covered wire (approximately 30 s.w.g.) on the long wave slab aerial (FS_4) in the same direction as the aerial coil, and over the centre of the existing winding. (See Figs. 2 and 5.) Connect additional winding to black eyelet, as illustrated.
3. Mount the Medium and Long wave slab aerials on the *inside* of the back panel, securing with a fine cord (such as dial drive cord) looped through holes T for the Medium wave aerial and holes F for the Long wave aerial, referring to Figs. 3 and 4.
4. Mount transformer T_2 on the rear panel using holes R and S. Secure with 4BA screws and nuts, with a 4BA solder tag at R. The transformer fly leads should be on the inside.
5. Mount transformer T_1 on the rear panel by pushing the lugs of its shroud through

holes P and Q and bending them towards each other. The primary winding (marked with a red spot) should face outwards.

6. Fit L_7 (green tags) in hole N with the tag ring in the position shown in Fig. 4, and glue into position.

7. Fit L_8 (yellow tags) in hole K with the tag ring in the position shown in Fig. 4. Glue into position.



A top view of the top panel and an outside view of the back panel. This diagram will assist in the identification of holes referred to in the text

8. Fit the transistor holder for TR_1 in hole L with the tags in the position shown in Fig. 4.

9. Fit the transistor holder for TR_2 in hole M with the tags in the position shown in Fig. 4.

10. Connect the green eyelet of the Medium wave aerial to eyelet 2. Connect the green eyelet of the Long wave aerial to eyelet 2. Connect the black eyelet of the Long wave aerial to eyelet 4. Connect the emitter tag of TR_1 holder to eyelet 4. Connect eyelet 4 to the solder tag at R. Connect eyelet 4 to tag 4 of L_8. Connect eyelet 6 to tag 1 of L_8. Connect tag 4 of L_7 to collector tag of TR_1 holder. Connect tag 1 of L_7 to tag 1 of transformer T_1. Connect tag 2 of T_1 to eyelet 3. Connect base tag of TR_2 holder to tag 4 of T_1. Connect emitter tag of TR_2 holder to solder tag at R.

11. Connect the blue lead of T_2 to collecto tag of TR_2 holder.

12. Connect the red lead of T_2 to eyelet 3.

13. Connect C_6 (2μF) from tag 3 of T_1 to the solder tag at R, with the positive end of C_6 at the solder tag.

14. Connect R_4 (47kΩ) from tag 3 of T_1 to eyelet 3.

15. Connect R_1 (220kΩ) from eyelet 2 to eyelet 3.

16. Connect R_2 (10kΩ) from eyelet 2 to eyelet 4.

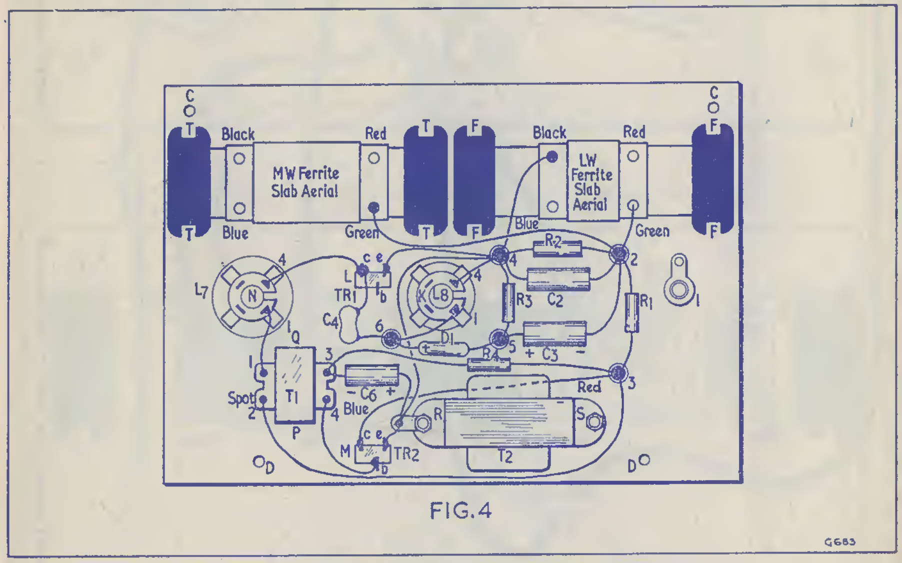
17. Connect C_2 (0.005μF) from eyelet 2 to eyelet 4.

18. Connect R_3 (10kΩ) from eyelet 5 to eyelet 4.

19. Connect C_3 (2μF) from eyelet 5 to eyelet 2, with the positive end at eyelet 5.

20. Connect diode D_1 from eyelet 5 to eyelet 6, with the cathode (red) end of the diode at eyelet 6.

21. Connect C_4 (100pF) from eyelet 6 to collector tag of TR_1 holder.



First steps in assembling the "Twinette"

The Top Panel

The following steps are illustrated in Fig. 5.

22. Mount C_1 (300pF) through hole J of the top panel (with the body of the condenser under the panel) in the position shown in Fig. 5, fitting a 0–10 dial plate under the securing nut.

23. Mount C_5 (100pF) through hole G of the top panel (body underneath, as C_1) fitting a 0–10 dial plate under the securing nut.

24. Mount the switch through hole H of the top panel (with its body under the panel) so that its tags are in the position shown in Fig. 5. Fit the switch plate under the securing nut as shown in the photograph of the top of the receiver.

25. Fit two angle brackets to holes B of the top panel with 6BA screws and nuts, the longer arms being those bolted to the top panel.

26. Join the top panel to the rear panel by securing the angle brackets with 6BA screws and nuts through holes C of the rear panel.

27. Connect tag A of the switch to tag "a" of C_1.

28. Connect tag B of the switch to tag "b" of C_5.

29. Connect tag C of the switch to base tag of TR_1 holder.

30. Connect tag D of the switch to the positive battery connector *via* a 1ft length of red flexible wire.

31. Connect tag 1 of the switch to the red eyelet of the Long wave aerial.

32. Connect the free end of the Long wav aerial reaction winding (fitted in step 2) t tag 4 of the switch.

33. Connect the free end of the Medium wave aerial reaction winding (fitted in step 1) to tag 5 of the switch.

34. Connect tag "a" of C_5 to the collector tag of TR_1 holder.

35. Connect C_7 (100pF) from tag "a" of C_1 to the solder tag at eyelet 1.

36. Connect C_8 (100μF) from eyelet 3 to solder tag at R, its positive end being at the solder tag.

Final Wiring

The following steps are illustrated in Fig. 6.

37. Connect tags 10 and 11 of the switch together and then to tag "b" of C_1, carrying on to the black eyelet of the Long wave aerial.

38. Connect tag 8 of the switch to the blue eyelet of the Medium wave aerial.

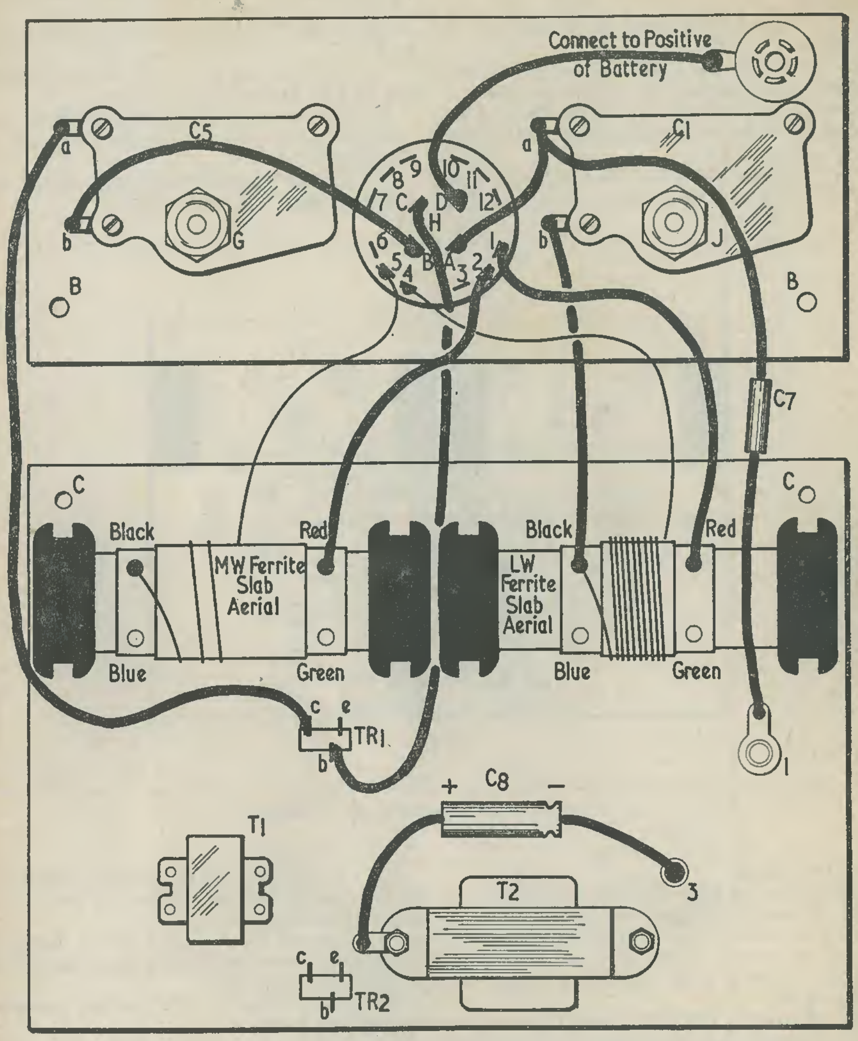


FIG.5

Fitting and wiring the components on the top panel

G684

39. Connect tag 7 of the switch to the blue eyelet of the Long wave aerial.

40. Connect together the black eyelets of the Medium and Long wave aerials.

41. Connect eyelet 3 to the negative battery connector *via* a 1ft length of flexible wire having a colour other than red.

42. Fit two angle brackets to the top panel with 6BA screws and nuts at holes A, the longer arms of the brackets being bolted to the top panel.

43. Fit two long U-brackets to the rear panel at holes D, using 6BA screws and nuts.

44. Remove the enamel from one of the secondary leads of transformer T_2, tin, and solder to tag at R.

45. Remove enamel from other secondary lead of T_2, tin, and solder to one of the tags of the speaker.

46. Connect the remaining speaker tag to the solder tag at R.

47. Connect the red eyelet of the Medium wave aerial to tag 2 of the switch. (See Fig. 5.)

48. Fit a solder tag at either of the points D and connect to solder tag at R.

49. Bolt the speaker to the brackets fitted in steps 42 and 43, as shown in the photograph of the chassis. Use 6BA screws and nuts, with a 6BA washer under each screw head.

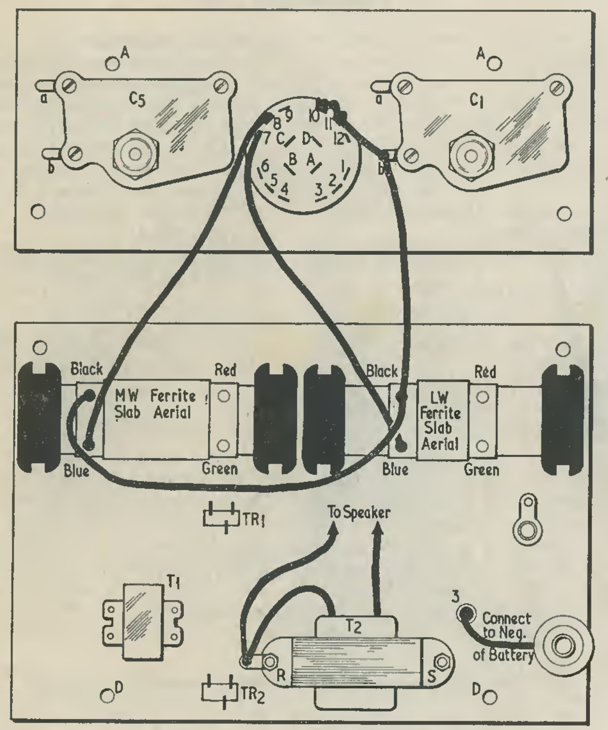


FIG.6

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Final steps in wiring and assembly

50. Insert TR_1 (OC44 or XA104) in the TR_1 holder, and TR_2 (OC71 or XB102) in the TR_2 holder.

51. Fit pointer knobs to the spindles of C_1, C_5 and the switch.

52. Connect the positive battery connector (red lead) to the positive terminal of the battery, and the negative connector to the negative terminal of the battery, taking care to ensure correct polarity.

Final Details

The "Twinette" is now complete and ready for operation. Tuning is carried out by adjustment of C_1, C_5 controlling reaction. Greatest sensitivity and selectivity will be given when the reaction setting is just below oscillation point. If an external aerial is required this should be connected to the tag at eyelet 1. See Fig. 5. The eyelet at this position will accept a standard aerial plug.

The receiver will give adequate volume in its completed chassis state. To obtain optimum results the chassis should be fitted in a cabinet, the latter providing a baffle for the speaker.

Components List

Resistors
(All $\frac{1}{4}$ watt, 20%)
- R_1 220kΩ
- R_2 10kΩ
- R_3 10kΩ
- R_4 47kΩ

Condensers
- C_1 300pF variable (Jackson Bros.). Dilicon dielectric
- C_2 0.005μF, 250 w.v. (or less if available)
- C_3 2μF, electrolytic, 12 w.v.
- C_4 100pF, 250 w.v. (or less if available)
- C_5 100pF variable (Jackson Bros.). Dilicon dielectric
- C_6 2μF, electrolytic, 12 w.v.
- C_7 100pF, 250 w.v. (or less if available)
- C_8 100μF, electrolytic, 12 w.v.

Special Components
(All available from Repanco Ltd.)
- 1 Medium wave ferrite slab aerial type FS3
- 1 Long wave ferrite slab aerial type FS4
- 1 R.F. choke type RF_1 (L_7)
- 1 R.F. choke type RF_2 (L_8)
- Top and rear panels, with brackets. (Group board type 6/T)
- 1 Interstage transformer, ratio 4.5 to 1, type TT14
- 1 Output transformer, type TT5
- 1 Set of 3 dial plates.

Transistors
- TR_1 Mullard OC44 or Ediswan XA104
- TR_2 Mullard OC71 or Ediswan XB102

Diode
- D_1 Mullard OA81

Miscellaneous
- 2 Transistor holders, Cinch type 81/001
- 2 Transistor holder clips, Cinch type 77/765
- 1 4-pole 3-way switch, miniature
- 1 7in x 4in elliptical speaker, Elac
- 3 Pointer knobs
- 1 Battery type PP4, Ever-Ready
- Nuts, bolts, washers, etc.

Catalogue received

Surplus Radio Supplies (Poldew Ltd.), 2 Laing's Corner, Mitcham, Surrey, have forwarded to us a copy of their Radio Component List. Comprising some 17 pages plus cover, this List includes a vast range of components at bargain prices, practically every item being well below current price ranges. Of the components offered, 90% are not Government surplus but brand new and unused, many being manufacturers' discontinued lines and warehouse "overs". Readers may obtain a copy of this list direct from Surplus Radio Supplies (Poldew Ltd.), at 1s. 6d. (including postage).

Argosy Doppler Navigator uses EEV K350 Klystron

The new Argosy C. Mark I aircraft for R.A.F. Transport Command will be provided with a Marconi Doppler Navigator Type AD2300B which comprises a sensor, computor and display unit.

A K350 klystron, manufactured by the English Electric Valve Co. Ltd. is used in the transmitter/receiver (sensor) equipment as the transmitter source of power and by sampling at the mixer this klystron also provides the local oscillator signal. The K350 is a forced-air cooled, two resonator klystron with mechanical tuning covering the frequency range from 8,500 to 10,000 Mc/s. The output power is approximately 1W and this is obtained with low noise modulation and good frequency stability. Another feature of the K350 klystron is that it can be used at high altitudes without pressurising.

Getting Started on 2-Metres

PART I—AERIAL SYSTEMS

by J. N. WALKER, G5JU

This is the first of a series of articles written especially for the beginner interested in 2-metre operation. Our contributor, who has been active for many years in the 2-metre field, and who is associated with a well-known firm of Short wave component manufacturers, describes this month simple but effective aerial systems. Next month's article will describe a single valve converter and this will be followed by a description of the addition of an r.f. and i.f. stage to this basic design, these additional stages being fitted to the same chassis. A 2-metre transmitter will also be fully described in this series

WHILST PERHAPS SOME SORT OF RESULTS can be achieved on two metres by, say, attaching an odd length of wire to the input socket of a two-metre converter, it is much more satisfactory to employ an aerial designed essentially to work on this one band and no other. Further, because the size of elements in an aerial for the 144 Mc/s band is relatively small, it becomes entirely practical to build up multi-element arrays without occupying a great deal of space. Such arrays naturally become highly directive both in the horizontal and vertical planes and, with the resulting concentration of power in a beam, very substantial gain is secured. The ability of a receiver to make weak signals intelligible is then greatly increased whilst, on the transmitting side, there is a considerable step-up in the effective radiated power.

However, to start with quite a simple aerial can be used—for example, a straightforward dipole. The construction of such an aerial is illustrated in Fig. 1. It is preferable to use tubing, made of any of the commonly obtainable metals, to give sufficient bandwidth to cover adequately the whole of the band, $\frac{1}{4}$in or $\frac{3}{8}$in diameter material being quite suitable. The use of wire instead of tubing will unduly narrow the bandwidth but, if one is in a hurry to get some sort of aerial erected, two or three lengths of 14 or 16 gauge wire in parallel will perform fairly well, especially if the ends are splayed out an inch or two.

The dipole is fed at the centre with either twin cable of 80Ω impedance or 75Ω coaxial cable, both providing a good match. A better balance is achieved with the twin cable. With coaxial cable there is almost certain to be some pick-up (or radiation) from the outer screen of the cable, this giving rise to omni-directional effects, partly in the vertically polarised mode. Incidentally most amateur work is carried out using horizontal polarisation and, accordingly, the aerial proper should be mounted horizontally.

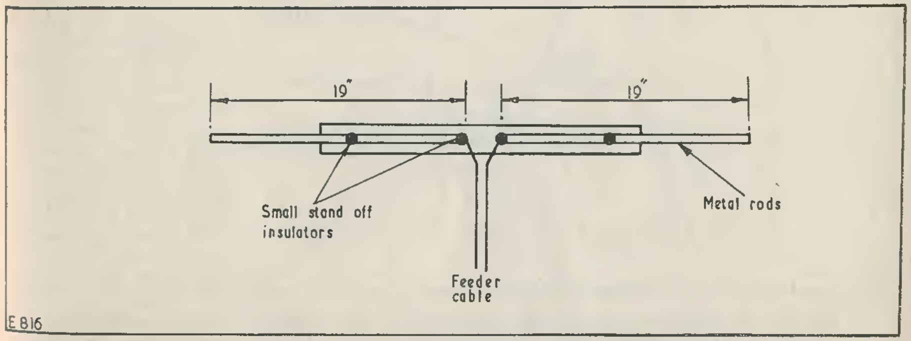


Fig. 1. A simple dipole aerial for the 2-metre band. Two lengths of metal tubing, four miniature stand-off insulators and a wooden support are all that are needed

To obtain the advantage of the figure-of-eight directional pattern given by a dipole, it is advisable to arrange for the dipole assembly to rotate through 90 degrees, or some signals may be missed.

Reflector and Director

Although the simple dipole gives some gain compared to an omni-directional aerial, this gain is not great. The addition of a reflector or director—or both—improves matters immediately by concentrating the beam mainly in one direction.

A complication arises here in that the centre impedance of the main element—the dipole itself—is reduced by the addition of further elements. However, with the addition of a single widely spaced reflector, as shown in Fig. 2, the mismatch with 80Ω or 75Ω cable is not serious and overall results will definitely be improved.

On making the array into a proper Yagi by adding also a director element, as illustrated in Fig. 3, the impedance at the centre of the dipole drops still more, to a value around 15Ω or 20Ω, whereupon something has to be done to correct the mismatch. The most satisfactory method, and the one generally adopted, is to convert the centre element into a folded dipole by adding another tube of the same length and diameter as the original but with no gap at the centre, as is shown also in Fig. 3. A transformation then results, stepping up the impedance by a factor of four, and so bringing the effective impedance back to near the 80Ω mark.

Still greater directivity and gain can be secured by adding a second director having the same length and spacing as the first. Beyond this the advantage per director added is reduced, as the beam becomes exceedingly directional and covers only a small angle. In the majority of cases using more than two directors is hardly worth while. Little or no advantage is gained by trying to use more than one reflector.

As before, either balanced or coaxial feeder cable can be connected to the centre of the dipole. Since now the array is uni-directional it becomes necessary to arrange to rotate it through 360 degrees.

Quad Aerial

The Quad type of aerial is well known as a good performer on the lower frequency bands and it is also quite effective on two metres. A design which has proved successful in practice is shown in Fig. 4, and, although heavy gauge wire may be used at a pinch, it is better to fabricate the elements from light tubing, to give a wider bandwidth. A reflector is normally used as shown and some further benefit will be secured by adding a director, of a total length somewhat shorter than the main element.

The polarisation of the Quad depends on the point at which the feeder is connected—as shown, the aerial is horizontally polarised.

A more elaborate design of Quad aerial was described in the September 1960 issue of *The Radio Constructor** and the dimensions given there can be readily scaled down, using

* "The Quad Plus", by A. S. Carpenter, *The Radio Constructor*, September, 1960.

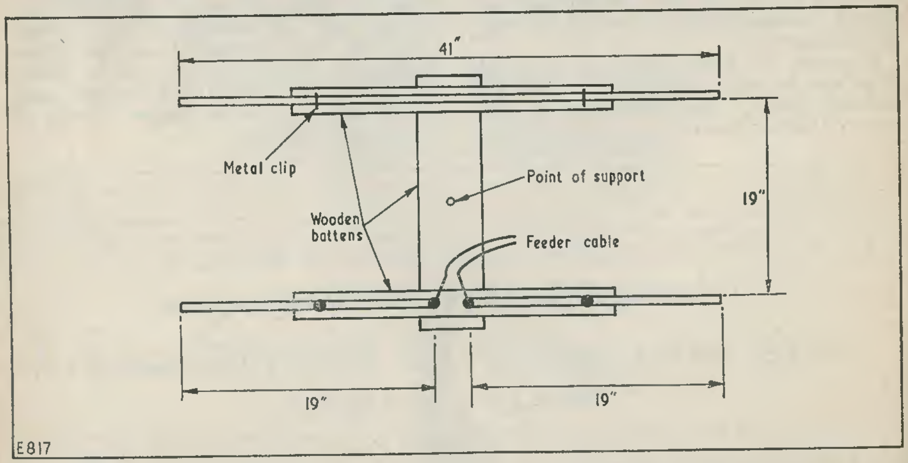


Fig. 2. An effective 2-metre wide spaced beam. The reflector is one continuous length of metal tubing, 41in long, whilst the radiator is split as in Fig.1. Any available wooden battens may be used and the reflector elements do not require to be insulated

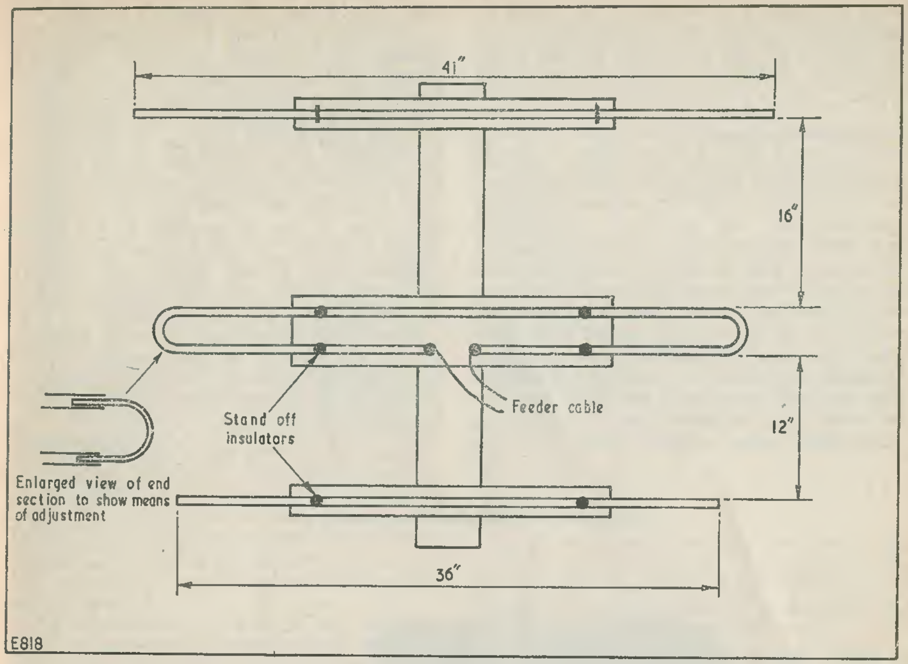


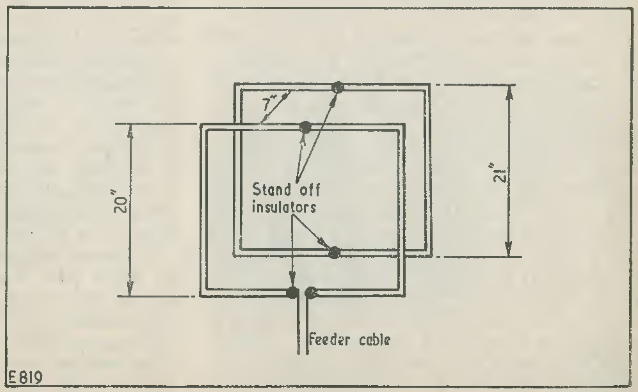
Fig. 3. A 3-element beam with folded dipole centre element. The metal tubing for the radiator should have a total length of 76in, including bends. To allow adjustments for resonance, make the ends a sliding fit inside the main tubes. These ends can be soldered when the aerial has been set up correctly

those given in Fig. 4 as a guide, to suit the two metre band.

Feeder Cable

Losses in feeder cable increase with frequency and the operator sometimes has to decide whether to erect his aerial array close to the station equipment where it may not be in too good a position, or at a more distant point which is in the clear but which involves a longer run of cable. The latter situation, giving lower absorption losses and less screening, is likely to prove the better provided a good quality cable is employed. Ordinary $\frac{1}{4}$in diameter t.v. coaxial cable and twin feeder is suitable only for comparatively

Fig. 4. Outline of a Quad aerial for 2-metre operation. The reflector is one continuous length of metal tubing with 21in sides. A suitable wooden framework should be constructed and the beam supported where insulators are indicated. The reflector is mounted directly behind the active loop



short runs (and for low power on the transmitting side). Where the cable length exceeds say 25ft, it is wise to employ heavier semi-air-spaced cable, with its much lower loss factor.

Testing for Resonance

Whilst the dimensions shown in the diagrams should bring the resonant frequency of the aerial inside the two-metre band variations can and do occur, these being due to the siting of the aerial, nearness of metal parts, and so on. In two recent cases where tests were made on aerials assumed to be correctly resonant, one Yagi assembly was found to resonate at above 150 Mc/s, whilst the other, a Quad, showed resonance at about 142 Mc/s. It will be appreciated that results in such cases are likely to suffer on both the receiving and transmitting sides—gain will drop and directivity may not quite follow the expected pattern.

For an easy and reliable method of testing, a calibrated grid dip oscillator should be used. A small loop of wire is formed and connected to the feeder termination. The coil of the grid dip oscillator is brought near to this loop and a pronounced dip should occur when the meter dial is swung over the correct frequency range. The frequency at which the dip is found should be as near as possible to the centre of the band i.e. 145 Mc/s., and this can be checked with a high degree of accuracy by tuning in the grid dip oscillator signal on the station receiving equipment.

Any small discrepancy can be ignored. If the discrepancy is considerable it will pay to adjust the length of the aerial radiator, shortening it if the observed frequency is too low, and *vice versa*.

(To be continued)

radio topics

BY RECORDER

In our November issue last year we gave details of exceptional Dx television reception, as achieved by Mr. I. C. Beckett, of Twyford, near Buckingham. We have since had a lively correspondence with Mr. George Petersen, of Ayr, North Queensland, Australia. Mr. Petersen, a radio engineer, has been carrying out some extensive t.v. Dx work (and has been hitting the local headlines in consequence!) and I don't think I can do better than quote from one of his letters detailing his experiences during 1960. Don't forget, when reading this letter, that Mr. Petersen's receiver will be a 625-line job having intercarrier f.m. sound. That is why he needs a local oscillator, beating with the incoming sound carrier, to cause the latter to be passed into his 5.5 Mc/s i.f. amplifier. (Sound-vision carrier spacing is 5.5 Mc/s in the Australian 625-line system, 4.5 Mc/s in the American 525-line system and 6.5 Mc/s in the Eastern European 625-line system; and all use f.m.) The footnotes in the letter are inserted by myself.

Mr. Petersen writes: ". . . Here in Australia I have put a considerable amount of effort into this same field. One of my main reasons was an unquenchable desire to come to grips with t.v. This was because the closest t.v. station to my location was 1,000 miles away.

"You will, of course, realise that conditions here are vastly different from those in Europe for Dx t.v. Firstly, the lowest frequency channel in Australia is Channel 2 (63–70 Mc/s)[1] yet I have had some quite remarkable reception from four of our Eastern Australian stations, particularly Melbourne (1,400 miles) and Adelaide (1,700 miles). This, of course, via the Sporadic-E layer during our midsummer months mainly. Other more rare periods of reception have been possible even at midwinter.

"Now on the more favourable lower frequencies I have to depend on t.v. stations 5,000 miles away to experiment with. Russian, Chinese, Korean, Hawaiian, as well as the 'local' Australian have been received.

"The receiver used is an Australian H.M.V. 23-valve 21-in, now almost three years old but recently modified by replacing the tuner with the latest type using frame grid valves. I give this all the help possible with good antennas. For the Australian Channel 2 I use a double-stack 10 element yagi. To cover the various Asiatic and Pacific t.v. signals and other v.h.f. transmissions a single big 10 element yagi is used, cut to favour our proposed Channel 1 (49–56 Mc/s).[2]

"Unfortunately, in spite of all this and even though signal strength from Russian and Chinese 49.75 Mc/s t.v. is quite remarkable at times, they are too often marred by a multitude of Japanese hams on 6 metres in contact with each other and also with some of the Australian 6 metre hams. Another Korean f.m. programme link on 48.3 Mc/s comes in with tremendous strength and quality for the greater part of the year.

"I should mention here that a 625-line 50 f.p.s.[3] receiver requires only minor adjustment to accommodate 525-line 60 f.p.s. signals.

"I use a small v.h.f. beat oscillator to extract the necessary 5.5 Mc/s sound of my Australian set from the 6.5 Mc/s Russian/Chinese signals and the 4.5 Mc/s of the American system. This same oscillator does a great job when receiving f.m. v.h.f. sound transmissions. Even a.m. transmissions are received with quite good quality by the same means; in this case, however, the resultant frequency should favour one side of the ratio detector, thus producing sufficient unbalance to produce sound.

"At the time of writing the most important of my photographs and tapes are in the hands of various Australian Government departments engaged in v.h.f. propagation research."

[1] 64.25 Mc/s vision carrier; 69.75 Mc/s sound carrier.

[2] 50.25 Mc/s vision carrier; 55.75 Mc/s sound carrier.

[3] Fields per second. (Frames per second in English terminology.)

The latest letter we have received from Mr. Petersen describes how he was able to receive a national event (namely the funeral of the Governor-General, Viscount Dunrossil), from Melbourne before the programme came generally on the air from Brisbane, Adelaide, Perth and Hobart. Lack of relay facilities prevented these cities from providing an instantaneous transmission of the event.

In this last letter Mr. Petersen states also that he is now photographing from the screen with an 8mm movie camera (16 frames per second) with results which are most gratifying.

We are much indebted to Mr. Petersen for his comments, and we would be interested to hear of any other instances of long distance t.v. reception. Where possible, details of such reception may be published in future issues.

Phonetic Alphabet

Another Australian reader (we seem to be getting very popular in that part of the world!), Mr. G. D. Clark, of Victoria, has passed on some comments concerning the joke alphabet I mentioned recently.

"I was very interested in the phonetic alphabet which you included in *The Radio Constructor* for December. I can remember learning this alphabet from a gramophone record about 35 to 40 years ago. There were certain topical references which would be lost on the younger generation; in my case there are some that I cannot remember but, for what they are worth, here are some variations and additions.

C for Highlanders	D for Ential
E for Adam	I for Novello
K for Ancis	N for a Dig
U for Films	W for a Bob

"Thank you for a very interesting column, and long may you continue to write it."

And I certainly agree with the last sentiment!

Build the "Malash" 5-Transistor T.R.F.

The monthly Soviet technical magazine *Radio* covers rather a wide range of subjects, these varying from articles (which may be fairly advanced) on general and topical electronic subjects to ham techniques and home-constructor projects. A recent issue features a receiver which appears to be simple and neat in design, and a few words about this may be of interest, especially if they reflect the Russian home-constructor scene.

The receiver (described by M. Romyantzi) is called the "*Malash*" (approximately "Tiny Tot") and it employs five p.n.p. transistors in a simple t.r.f. circuit. All transistors are connected in the earthed emitter mode. The single-band aerial input stage employs a ferrite frame, one winding of which is tuned by a 10–450pF variable condenser. This is the only tuning control in the receiver. A coupling winding on the ferrite frame connects to chassis via a 6,800pF condenser and to the base of the first transistor via a 470Ω resistor. The collector of the first transistor then connects to the primary of an iron dust or ferrite cored transformer, the secondary of which couples into a conventional series diode circuit. This transformer is small in size and is not tuned in any obvious way, although it may well, I suppose, be self-resonant at some point in the frequency band covered. After the diode we have an a.f. transistor, followed by the third transistor. This drives the output transistors via an a.f. transformer with a centre-tapped secondary. The two output transistors work in conventional push-pull manner (emitters to chassis in this case, and bias via the a.f. transformer secondary), and their collectors connect direct to the two outside terminals of the centre-tapped speaker voice coil. The whole receiver is powered by a 4.5 volt battery.

Several components in the circuit provide top-cut. There is, for instance, a 6,800pF condenser between the base of the second transistor (that immediately following the diode) and chassis; although this may also provide an r.f. circuit for the diode. A 510pF condenser is connected between the collector and base of the driver transistor. Finally, a 3,000pF condenser is connected across each half of the speaker voice coil.

There is no stabilising in the receiver and circuitry is economic, there being eight resistors and eight condensers (including the tuning condenser). The whole receiver is mounted on a printed circuit board.

The receiver has one control only, the tuning condenser. This is operated by a large knurled disc which carries a projection at one point. When set to full capacity this projection operates a pair of contacts which switch off the receiver. The disc carries a set of numbers ranging from 344 to 1734, which are viewed through an aperture in the cabinet. If these are kc/s, the range of the receiver would be some 173 to 872 metres. Such a wide range is feasible, considering the lack of stray capacities across the tuned circuit.

It would seem that rechargeable batteries are used with the receiver, because a separate drawing illustrates a simple charging device. This consists of a two-rectifier circuit in series with an 0.01μF condenser. These components are mounted in a plug which connects to the 127 volt a.c. mains supply. The condenser limits the a.c. current to the rectifiers, and the batteries receive their charge via two fly-leads.

News in Brief

The Royal Air Force has formed a Tape Recording Society, which is affiliated to the Federation of British Tape Recording Clubs. The Society will provide a link between recording clubs on R.A.F. stations at home and overseas. Events of interest, such as boxing, football, races, concerts, etc., will be taped and the recordings circulated. One of the declared aims of the Society is to provide a service for hospital patients, blind persons and other handicapped people. Membership is open to past and present members of the R.A.F., the W.R.A.F., Princess Mary's R.A.F. Nursing Service, and to personnel of N.A.T.O. and Commonwealth air forces. I haven't the address of the hon. secretary of the Society at the time of writing, but I hope to pass it on next month.

Electrolube, that very well known contact cleaning fluid, is now available in an "aerosol" dispenser. You press a button on the container and the fluid is released in a fine spray. The Electrolube "aerosol" dispenser has been developed in response to many requests from British users, and enables the fluid to be sprayed directly on to working commutators, switches, and contacts, whereupon it combines the actions of loosening tarnish, lubricating and spark inhibiting. The new dispenser was demonstrated for the first time at the *Salon International des Composants Electroniques* in Paris during 17th to 21st February.

Radial, the official journal of the Radio Amateur Invalid and Bedfast Club, has a lively February issue which includes details of a parallel American organisation. London members of the R.A.I.B.C. have now set up a very successful 2 metre Net.

"The transistor portable that just went on and on." That is what happened with a Philips "Philette" which was badly damaged in a fire in Grimsby. The receiver continued playing whilst firemen tackled the blaze, even though much of the case melted, the tuning indicator dial disappeared and the control knobs were lost. Three weeks later the set was still working. It could not be switched off because the on-off switch was also melted! The set was then sent, merrily playing away, 160 miles through the parcel post to Philips Electrical Ltd., at Century House, W.C.2, where it still continued working uninterruptedly. A photograph shows the receiver with most of the top half of the cabinet melted away and part of the speaker and chassis completely exposed.

GROUPBOARD TECHNIQUES

by IAN GARDNER

Our contributor offers useful advice on constructional techniques with the latest groupboard methods of assembly

Since the introduction of miniature and subminiature components—especially those designed for use in transistor circuits—increasing use has been made of groupboards for the building of equipment. These groupboards are made of various insulating materials and may have the circuit connections etched in copper foil on one side or they may be wired. Such groupboards may be used in conjunction with more conventional chassis forms, as sub-assemblies, or they may be mounted parallel and close to a front panel which is used to support any required controls, thus providing a very compact assembly.

Printed Circuit Groupboards

The materials used for printed circuit groupboards are generally either resin bonded paper (Paxolin), fibreglass or laminated plastic to which is bonded a sheet of copper foil about 0.002in thick.

By various processes, including one which may be carried out by the home constructor and for which a kit is available, the copper foil may be etched in such a way that separate conductors are formed. These conductors are usually of the order of 0.04in wide, having connection spots about 0.10in dia. between which components are mounted. Components are mounted on the opposite

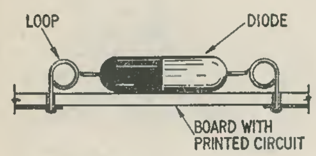


FIG. 1
MOUNTING OF CRYSTAL DIODE ON PRINTED CIRCUIT BOARD

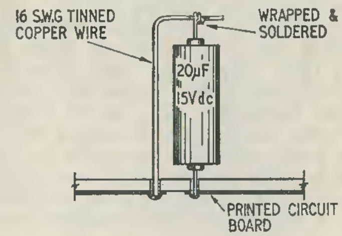


FIG. 2
VERTICAL MOUNTING OF SMALL ELECTROLYTIC CONDENSERS

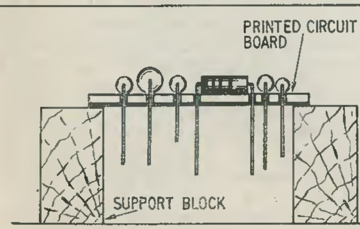


FIG. 3A
PRINTED CIRCUIT BOARD ASSEMBLY — STAGE 1

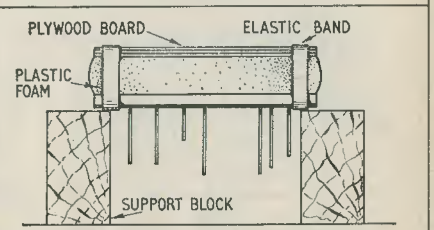


FIG. 3B
PRINTED CIRCUIT BOARD ASSEMBLY — STAGE 2

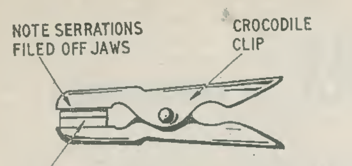


FIG. 4

MODIFICATION OF CROCODILE CLIP TO MAKE HEAT SHUNT

G677

side of the board to the printed circuit.

Resistors and condensers have their wire ends passed through holes drilled at the connection spots. With home-constructed boards, care should be taken to drill the holes through the centre of the spots (using a No. 52 drill, 0.0635in dia.) and to avoid tearing the copper foil from the board.

With commercially produced printed circuit boards, the hole spacing is normally such that the wire ends of resistors and condensers must be bent at 90° no closer than about 3/16in from each end of the components. This arrangement should be maintained when designing printed circuit layouts.

Although special printed circuit valve bases are available, standard B7G and B9A valve bases may be modified easily by removing the fixing lugs and filing the connection spills to half their width. The valve base connection spots on the printed circuit board should then be drilled out to suit and a hole drilled in the centre to take the centre spigot of the valve base, which may then be connected to the nearest earth point.

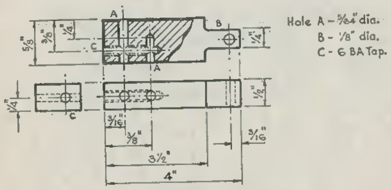


FIG. 5

JIG FOR MAKING SINGLE ENDED OR DOUBLE ENDED PINS

The Jig should be made of ½" thick mild steel. By means of the tapped hole 'C' the 1/16" dia. brass rod may be held for cutting and filing in either of the 'A' holes (depending upon the Pin required) with a 6 BA bolt

G678

Crystal diodes should have their wire ends looped as shown in Fig. 1.

Transistors are best held in rubber or polythene sleeves which are glued to the board, the leads being insulated with coloured sleeving, this serving identification. The wire ends should be looped in the same manner as diodes.

In order to save space, small electrolytic condensers may be mounted vertically as shown in Fig. 2. It is advisable that such components should be mounted last.

Small transformers may be clamped or bolted to the board, their connections being made to the appropriate points with short wires. Large transformers are usually mounted on a metal chassis together with switches, potentiometers, etc., the printed circuit board being fitted as a sub-assembly.

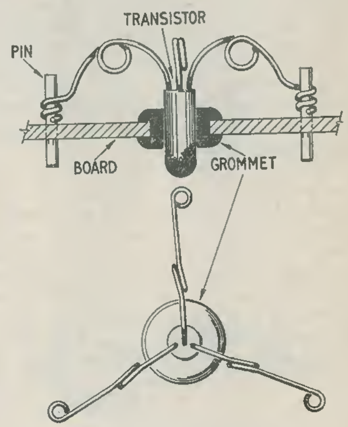


FIG. 6

MOUNTING OF TRANSISTORS

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Soldering

It is convenient to do all the soldering at one and the same time. To support all the components neatly on the board, the following method has been successfully employed.

First clean up the printed circuit conductors by rubbing the board with a fine grade of wire wool.* Tin all the wire ended components and bend the wires to 90° suiting the fixing hole positions. Assemble the components on the board, the latter being supported upon two blocks as shown in Fig. 3 (*a*).

When all the components are in place a piece of foam plastic about ½in to 1in thick and a piece of ⅛in thick plywood, which have been previously cut to the dimensions of the board, are placed as illustrated in Fig. 3 (*b*). Elastic bands are then slipped over the ends as shown so that the board may be turned over, the soldering completed, and the excess wire ends severed.

When soldering printed circuits, care should be taken to avoid overheating either the components or the copper conductors as the latter may tend to peel from the board. The minimum quantity of solder to effect a secure joint is required and a soldering iron having a small bit should be employed.

It is advisable to solder transistors separately in order to allow a heat shunt to be used. An easily made heat shunt using a crocodile clip and a spare soldering iron bit is shown in Fig. 4.

Pin Type Groupboards

This type of assembly provides an inexpensive and neat method of building equipment in board form without the use of printed circuits. Materials used for these boards may be resin bonded paper, fibre-glass or Perspex. Thicknesses may vary from 1/16in to ¼in, a thickness of ⅛in being generally used on account of its mechanical rigidity when heavy components are required to be mounted.

Large components are bolted or held by clips to the board, and resistors, condensers, etc., are supported between brass pins which may be of such a length that they protrude an equal length on each side of the board when in position, thus allowing components to be mounted on one side of the board and the wiring on the other. Shorter pins are also used when it is desired to have components and wiring on the same side, should an extremely shallow assembly be required.

Suitable pins for home constructed boards may be cut from 1/16in dia. brass rod using the jig illustrated in Fig. 5 to ensure uniform lengths. The pins are tapped lightly into holes which should be drilled with a No. 53 drill (0.0595in dia.) using the jig to support the board so that the hole "B" is directly below the hole drilled for the pin.

When designing a layout on this type of board pins should be spaced so that about 3/16in of wire is left between the pins and the ends of components. Common pins may be used to link components in series or parallel but three wires should normally be the maximum for any pin. Adjacent pins should not be mounted closer than ¼in. A row of pins on one side of the board facilitates power supply and other connections.

Resistors and condensers should have their wire ends trinned and wrapped once round the pins before soldering.

Transistors should be mounted in rubber grommets with their leads sleeved and

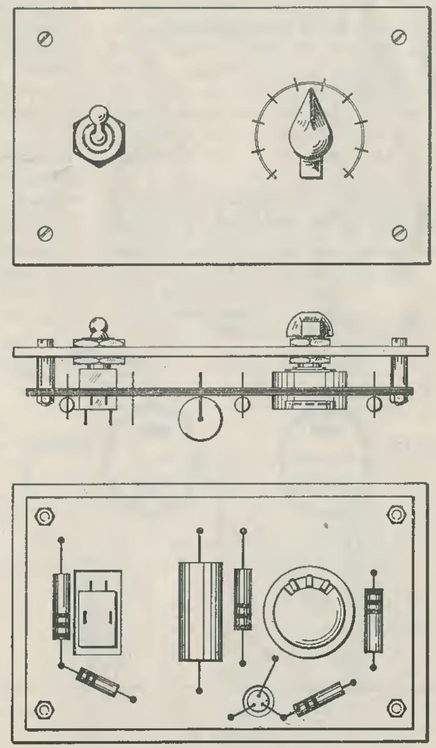


FIG. 7

ASSEMBLY OF PANEL AND GROUPBOARD

G680

* Some commercially produced printed circuit boards have a coat of protective lacquer on the copper side which functions also as a flux. If such boards are in good condition, cleaning by abrasion should not be necessary.—*Ed.*

brought out to pins as shown in Fig. 6. The leads should not be shortened but looped, and a heat shunt used when soldering.

Valveholders may be mounted as on a normal chassis or, by the use of suitable brackets, they may be mounted parallel to the board.

Before inserting pins into a drilled board, the component circuit references may be marked or stencilled using black or white indian ink.

A typical groupboard assembly is illustrated in Fig. 7. The control panel supports a switch and a potentiometer and the groupboard is mounted upon spacers about ⅜in behind the panel. The switch and potentiometer terminals are accessible through holes in the board.

ELECTRONIC VIBRATO

for Amplified Musical Instruments

by BRIAN L. PHILLIPS

The reader will be familiar with the "vibrato" effect used on electronic organs, from the massive Hammond to the small Clavioline, as well as with the present very popular electric guitar. There are various systems employed to give this effect, but they all produce the same desired result, namely, they modulate the incoming audio signal and give it a characteristic "beat".

In a large number of commercial designs a simple low frequency oscillator is used to modulate the anode supply of an audio amplifying stage, thus varying the output of this stage at the rate of the oscillator frequency. Unfortunately there are one or two serious drawbacks to this system. The most important is that the oscillator is directly connected to the audio signal path (see Fig. 1); thus unless a high-pass filter is employed after this point, the oscillator signal will appear together with the audio signal at the amplifier output. This gives a most unpleasant "thumping" sound. Another drawback is that deep modulation of the signal is impossible without increasing the number of stages in the oscillator to obtain a large voltage change at its output.

Sometimes a multivibrator oscillator is employed and, under favourable conditions of operation, good results are possible; but invariably the early stages of the amplifier pick up the harmonics from the oscillator, which again appear in the output as "clicks".

The writer has, over the last three years, conducted extensive tests with electronic vibrato and the following circuits will be found to be free from undesirable traits.

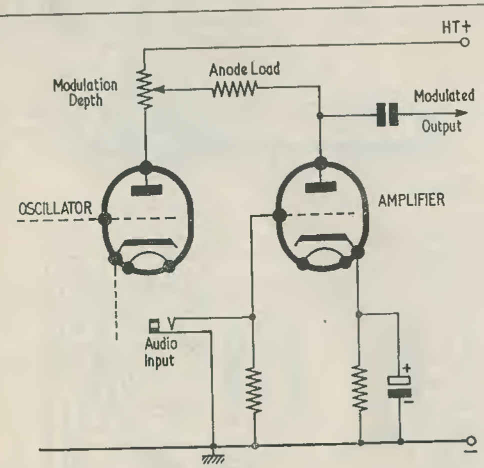


FIG. 1

BASIC MODULATION CIRCUIT, WHERE ANODE VOLTAGE OF AMPLIFIER IS VARIED BY OSCILLATOR

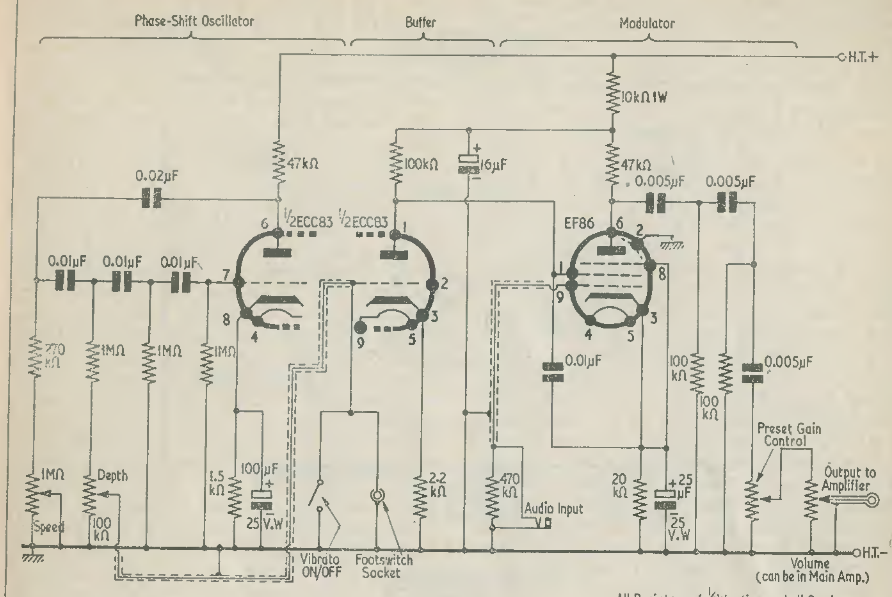


FIG. 2

CIRCUIT OF VIBRATO UNIT

Circuit Operation

The unit, whose circuit is shown in Fig. 2, is connected between the input and the amplifier itself, since under low signal level conditions, it is very easy to modulate the audio before passing it on for normal amplification. No gain is given by the unit, this being set up such that the output voltage is the same as the input, except for the modulation. It may be powered by the parent amplifier, or driven separately from the mains, whichever is required. Details are given for both methods.

The oscillator employed is the phase-shift

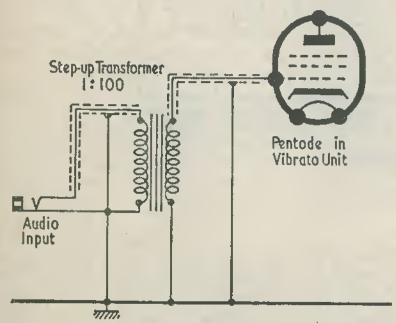


FIG. 3

THE INPUT CIRCUIT EMPLOYED WITH LOW IMPEDANCE INSTRUMENTS

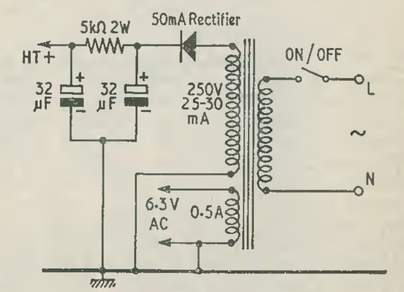


FIG. 4

POWER PACK FOR MAINS OPERATION OF UNIT

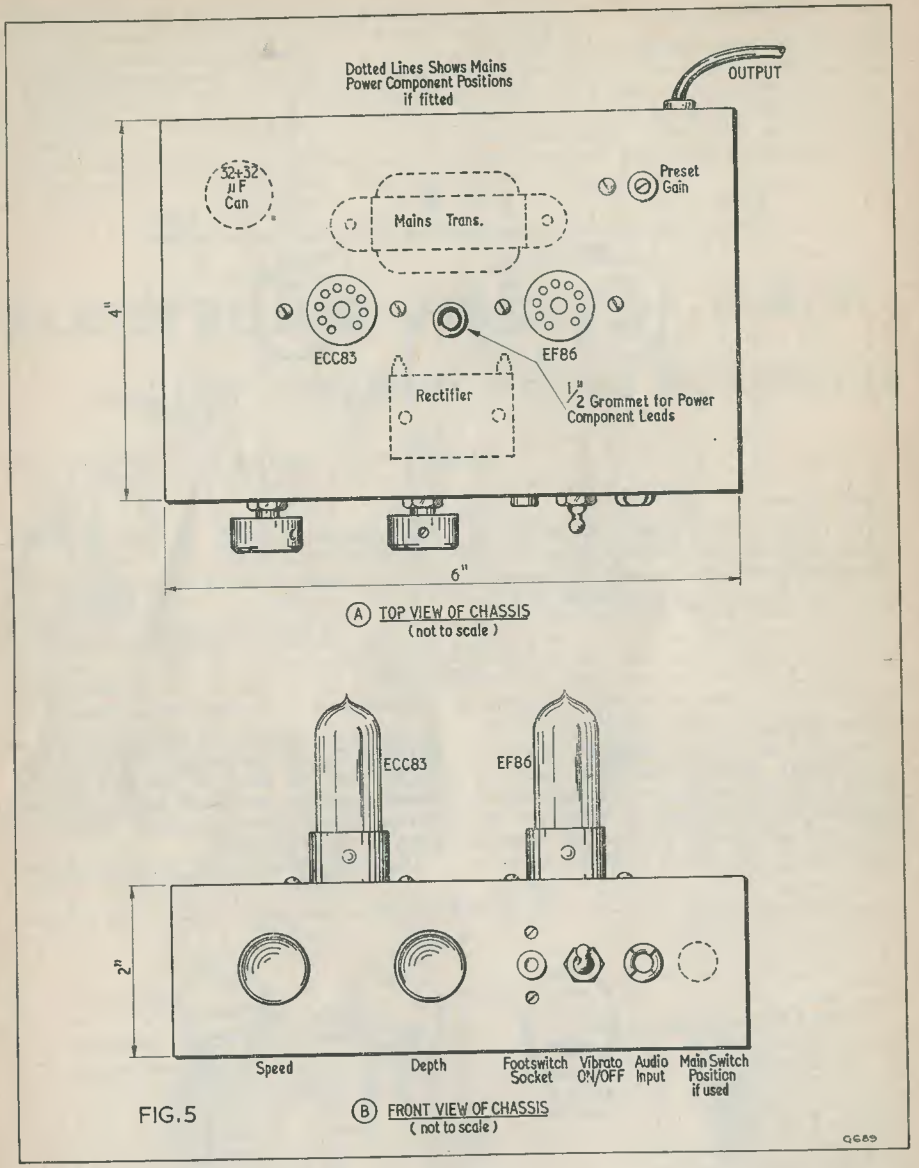


FIG.5

(A) TOP VIEW OF CHASSIS (not to scale)

(B) FRONT VIEW OF CHASSIS (not to scale)

type, generating a very pure sine wave at between four and fifteen cycles per second. Oscillation is maintained by positive feedback between anode and grid via the phase changing network. The frequency of oscillation is controlled by the total time constant of this network, the variable element being one of the resistors, this giving a wide frequency or "speed" range. The output is taken from a low potential point in the network by tapping into the "earthy" end of one of the other resistors. This avoids affecting the oscillator frequency; and, by making the lower portion of this resistor a potentiometer, a variable output or "depth" control is available.

This output is coupled to the control grid of a triode buffer stage which, apart from isolating the oscillator from the rest of the unit, brings the oscillator output up to a level suitable for modulating the audio amplifier.

The modulated stage consists of a pentode, and the modulating voltage is injected into the screen-grid from the buffer anode circuit. As is well known, the gain of a pentode can be readily altered by varying the screen-grid voltage; and as this voltage is varying in sympathy with the oscillator frequency, the overall gain varies at this frequency. To improve this condition, a high level of bias is applied to the grid of the pentode by employing a high value of cathode resistor. Thus any audio signal applied to the pentode control grid will appear at the anode as a signal modulated at the same rate as the oscillator. To remove any oscillator fundamental from the output, a high pass filter is employed in the anode circuit. A pre-set gain control is also used at this point to set the overall gain at unity, so that the input to the parent amplifier is the same as if the unit were not in circuit. The gain control on the parent amplifier is used to alter the signal level. There is a coaxial socket for a footswitch to operate the vibrato on and off, if required. Across this socket is a master on/off switch enabling the vibrato to be switched off from the unit itself if a foot switch is not available. The other socket is a closed circuit jack for the audio input. The output lead to the amplifier is permanently attached to the unit, the amplifier end of the lead terminating in a plug suitable for the input socket used, or, if the unit is made a permanent part of the amplifier, connected to the input within the amplifier.

Chassis

The layout of the unit is in no way critical, but screened lead *must* be used where indicated on the diagram to avoid hum pick-up. If the unit is to be used externally to an amplifier, it is best housed in a small box made either of sheet steel or, at least, 16 s.w.g. aluminium. Five ply-wood is also suitable. If it is to be mounted in the amplifier cabinet, then all that is required is a convenient corner where the chassis can be mounted and where the controls can be easily adjusted.

Safety Precautions

Some makes of amplifier used with musical instruments employ the a.c./d.c. technique of operation. To conform with safety standards the inputs to these amplifiers, and all external metalwork, have to be isolated from the mains supply. Some types employ isolating condensers, but the most frequently used method of isolation is to couple the inputs to the first stage by 1:1 ratio transformers. As is well appreciated, "live" metalwork is not to be recommended on any mains operated equipment; least of all when the equipment will probably be used by somebody who knows little about mains polarity; so all external connections to an amplifier *must* be isolated.

If the vibrato unit is to be used with an a.c./d.c. amplifier it should be provided with its own power supply employing an isolating mains transformer. The only connection to the amplifier will then occur at the input terminals of the latter and, since these should be reliably isolated, there should be no direct connection between the mains and the chassis of the vibrato unit. If the amplifier employs an isolating mains transformer and its chassis is not connected directly to the mains, the vibrato unit may either draw h.t. and heater power from the parent amplifier, or be fitted with its own isolated power supply. When operated from the main amplifier, the h.t. positive connection is best taken from the h.t. rail just after the smoothing network, the negative side (chassis) being connected to the amplifier chassis near the input stages. A good thick earth connection between the two chassis is recommended to reduce hum effects.

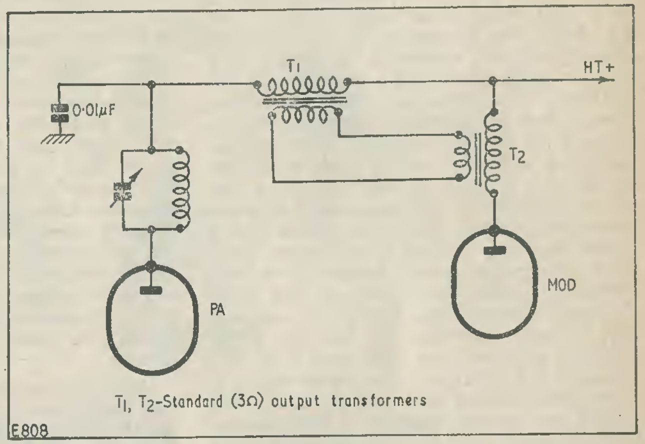
When the input to the main amplifier is at low impedance it will be necessary to fit a step-up transformer (1:100) at the input to the vibrato unit, this employing the circuit shown in Fig. 3. This step-up transformer could be obtained from the main amplifier. The main amplifier will now require a 1:1 input transformer in place of the step-up transformer previously employed. Such a transformer *must* have insulation between primary and secondary, and between primary and core, which is fully suitable for mains isolation.

For separate mains operation, a suitable power pack is shown in Fig. 4, this consisting of an isolating transformer supplying 250 volts at about 25–30mA and 6.3 volts at 0.5 amp. A small pre-amplifier mains transformer is ideal. The rectifier is a contact-cooled type of 50mA rating. A conventional metal rectifier may, of course, be used if one is to hand. A suggested chassis layout is given in Fig. 5, and this can be employed in the "built in" version, or as the external unit; the only difference being that the latter will be mounted in a case or cabinet.

It is important to note that, if the vibrator unit chassis is fitted in the same cabinet as an a.c./d.c. amplifier, there must be no electrical connection whatsoever between the two chassis other than that between the vibrato unit output and the input terminals of the amplifier.

USEFUL TRANSFORMER TIP

by S. G. Wood, G5UJ



T_1, T_2—Standard (3Ω) output transformers

For anyone not in possession of a modulation transformer—often a not inexpensive item—the following tip may be of interest. Where a small modulation transformer is required, as in the case of a Top Band QRP transmitter, quite a useful alternative can be made up with two standard output transformers connected "back to back". (See diagram.)

These two transformers may conveniently be of the 3Ω variety. It will be appreciated that power in excess of 10 or 12 watts should not be used unless appropriate heavy duty components are employed (suitable transformers are often to be found in quality amplifiers and similar equipment).

Though by no means an original idea, a friend of the writer has used this particular system in a Top Band c.w./phone transmitter for several months, and has given results comparable in every way with an orthodox modulation transformer.

BOOK REVIEW

INTRODUCTION TO HI-FI. By Clement Brown. 198 pages, 5½ x 8½in. George Newnes Ltd. Price 21s.

In his preface to *Introduction to Hi-Fi* Clement Brown writes: "This book has been written by a music lover who hopes that his contribution to the cause of high quality sound reproduction will encourage others to take an interest in it." This approach is maintained throughout the book, which deals in a very explanatory manner with all aspects of current high fidelity reproduction. The treatment is crisp and non-mathematical.

Mr. Brown commences with a chapter introducing high fidelity, and he ends with a look into the hi-fi world of the future. In between, the book covers records and pickups, amplifiers, radio tuners, loudspeakers, tape recording, stereo and listening room acoustics. Technical points in the text are clearly illustrated by diagrams and photographs. Also given is sound and practical advice on the purchase and installation of equipment. At the end of the book are several pages of useful data and a list of specially recommended recordings.

Introduction to Hi-Fi will be especially helpful to the novice, who will find that the subjects are covered clearly and carefully, without short cuts or any tendency towards "blinding with science".

J.R.D.

"An essential piece of equipment..."

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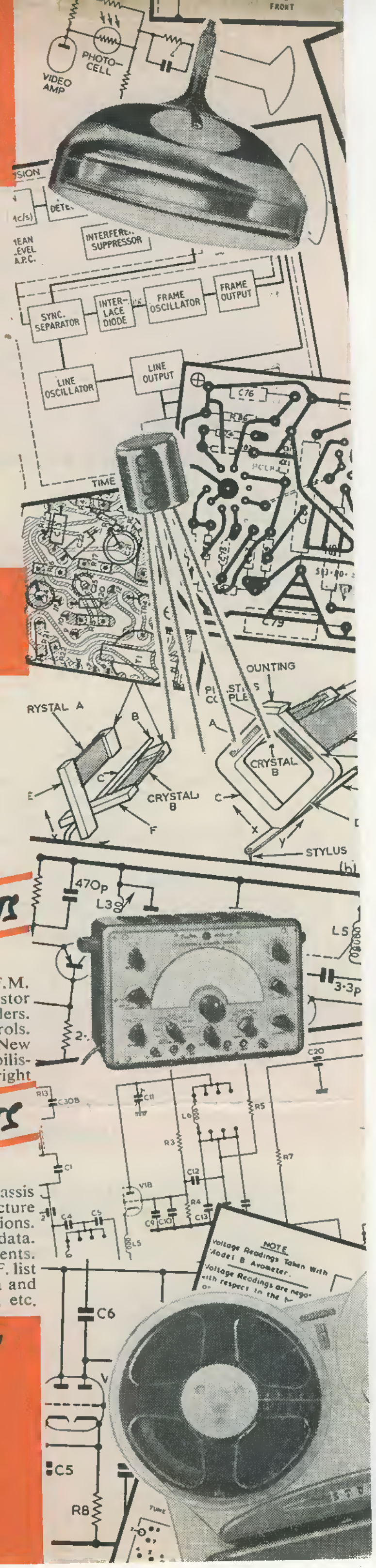

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