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 SERVICE-man 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

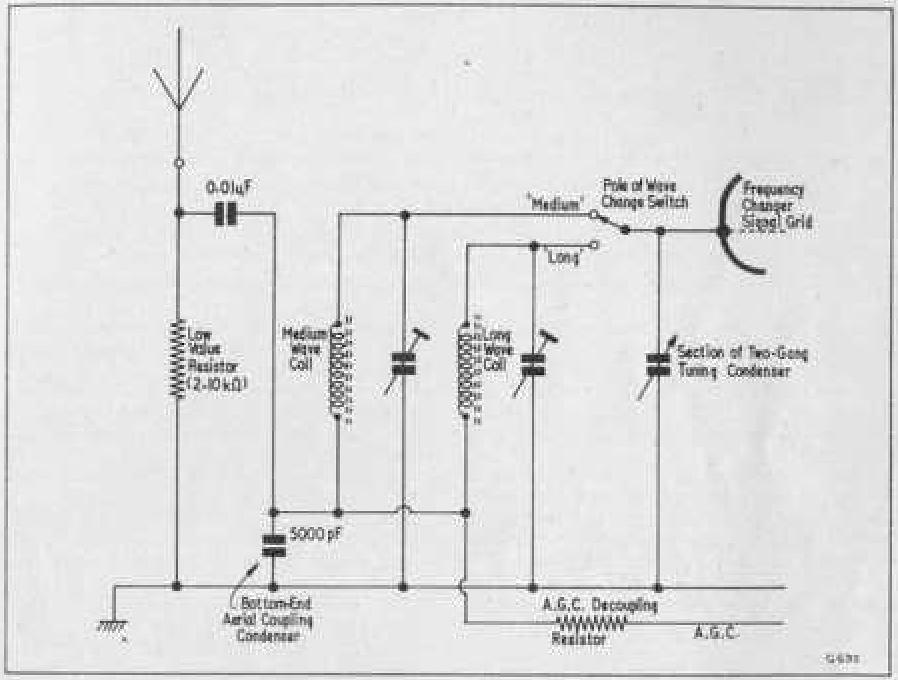

Fig. 1. A typical Medium and Long wave bottom-end coupled aerial circuit. The value given for the bottom-end coupling condenser (5,000pF) is typical of normal practice

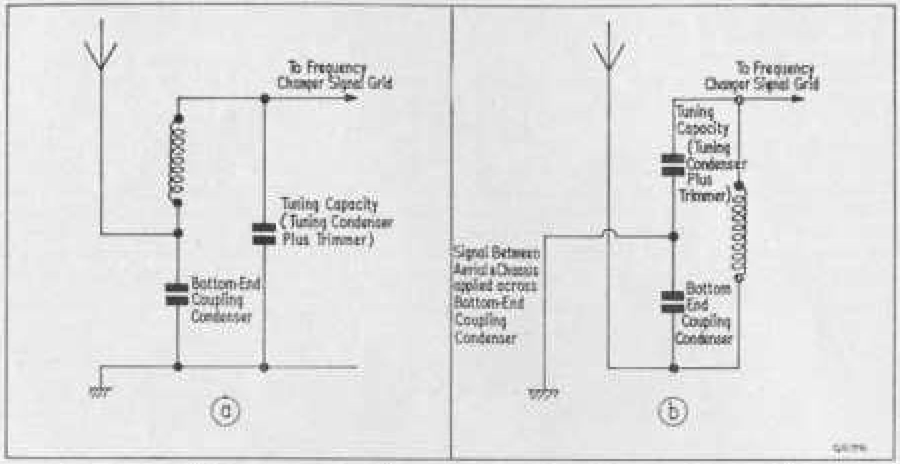

Fig. 2 (a). The bottom-end coupling circuit can be reduced to the simple form shown here

(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

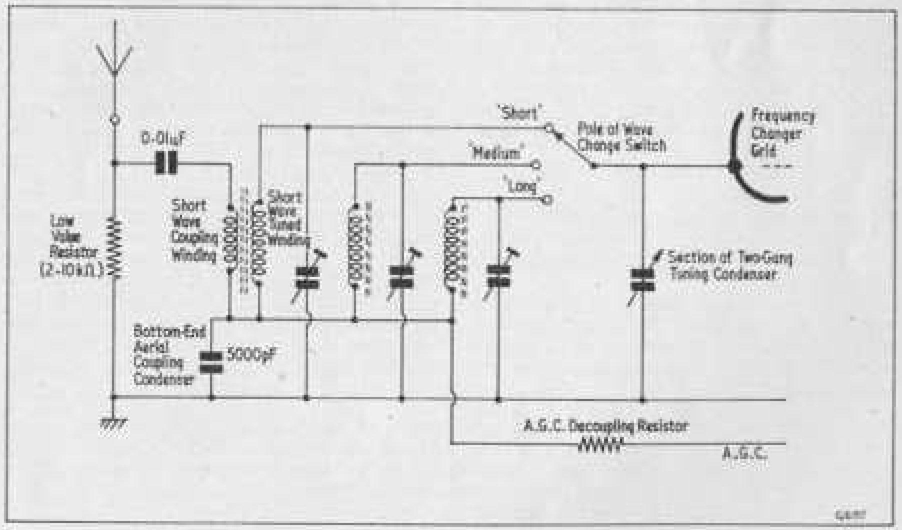

Fig. 3. Adding a Short wave range to the circuit of Fig. 1. The coupling winding of the Short wave coil is inserted in series with the aerial feed to the bottom-end coupling condenser, and its low inductance has little effect on Medium and Long wave performance. At the same time, the bottom-end coupling 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

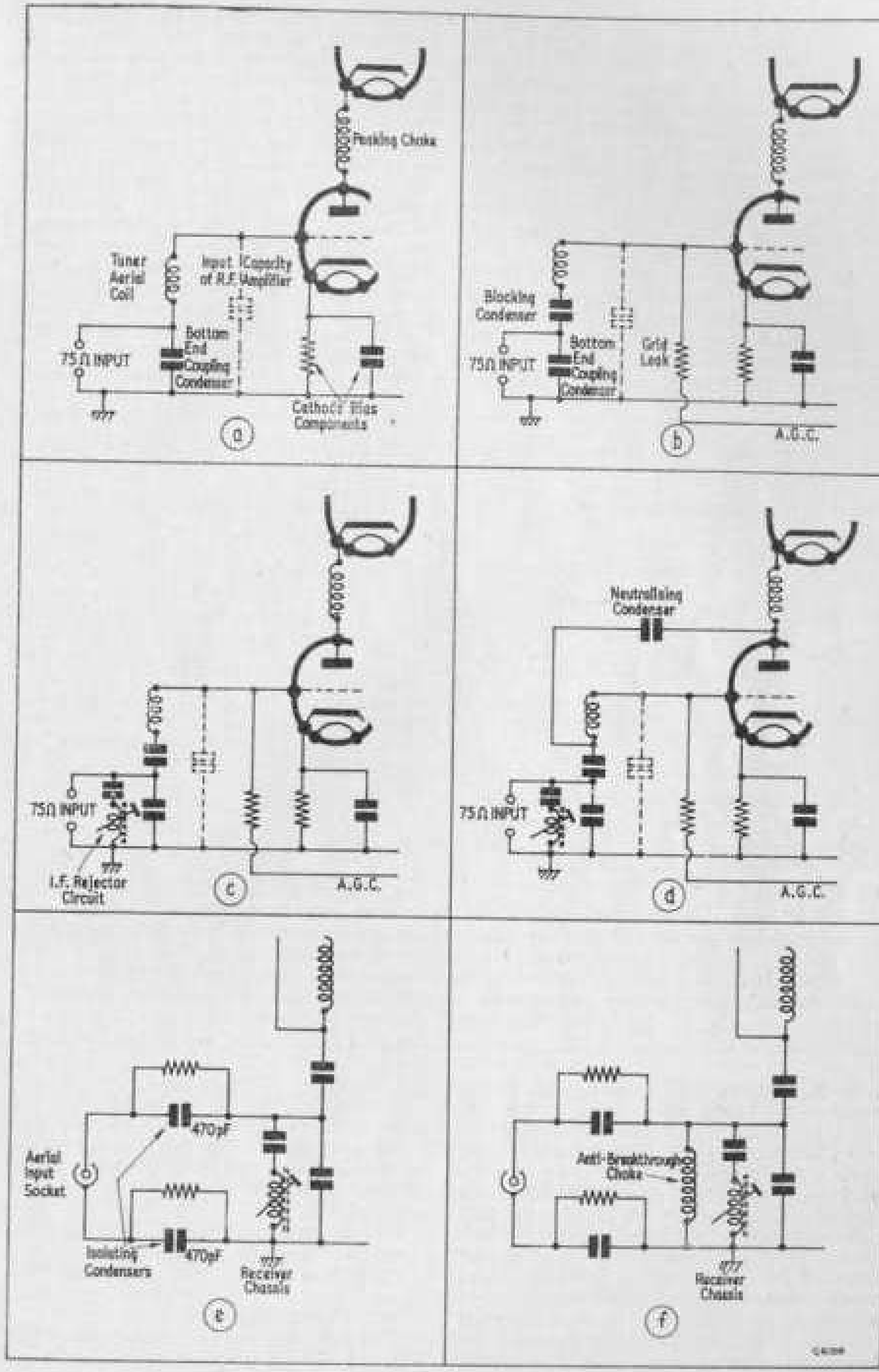

Fig. 4 (a). The basic input circuit of a television tuner using a single winding aerial coil. The triode shown here is part of a double-triode cascode r.f. amplifier
(b). In order that a.g.c. may be applied to the valve, it is necessary to add a blocking condenser and grid-leak
(c). An i.f. rejector 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

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

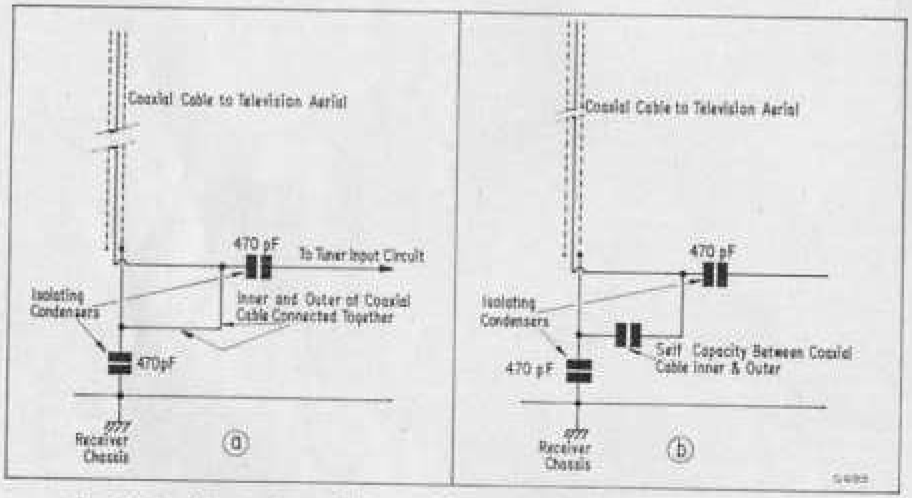

Fig. 5 (a). Showing how Medium and Long wave breakthrough is possible in a television tuner using a single aerial coil circuit. It is assumed here that the inner and outer conductors of the coaxial cable are connected together
(b). If the coaxial inner and outer conductors are not connected together 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

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?"

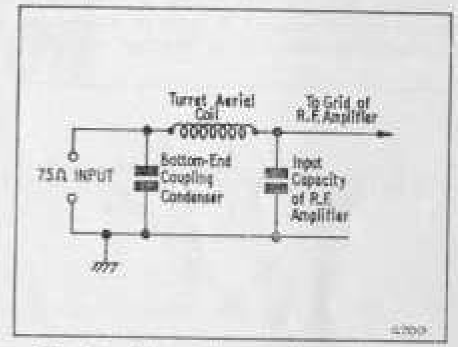

Fig. 6. When the tuned circuit components of Fig. 4 (a) are re-drawn as shown here they may be recognised as providing a pi coupling circuit

"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

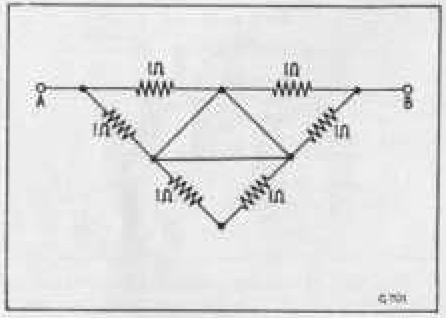

Fig. 7. Smithy's simple problem. What is the resistance between terminals A and B?

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