Supplement to The Wireless & Electrical Trader, September 26, 1942

"TRADER" SERVICE SHEET

589

AMERICAN MIDGETS

PART ONE: POWER SUPPLIES

IN response to many requests for information dealing with the servicing of American midget receivers, it has been decided to revise and reprint in the form of *Service Sheets* a series of articles, prepared in *The Trader* laboratory, which were published in the journal about two years ago and are now out of print.

Problems connected with the servicing of American midget receivers are bound to crop up frequently, because literally thousands of these sets are in use in this country, while only in a few isolated cases has even a circuit diagram accompanied any of them upon importation.

Some dealers have done a lot of business with this type of set, and their service departments have consequently become familiar with the "shape" of midget design, so that they can handle repairs to all kinds of midgets, because, although individual designs vary widely, certain general principles are followed fairly regularly. In some ninety cases out of a hundred the conventional service manual is quite unnecessary to the service man who has familiarised himself with the trend of their design.

General Circuit Design

For those who have not had sufficient experience to acquire this familiarity it is proposed in this series to discuss the general outline of midget receiver practice, at first dealing broadly with the most common arrangements of various parts of the circuit and then working round to the less frequently encountered arrangements, finally winding up with innovations and peculiarities which may be considered comparatively rare.

In general, it may be said that the midget is an AC/DC receiver, usually designed to be operated from 100-120V mains. In the early days of the midget invasion the sets were almost all TRF types comprising a four-valve combination of variable-mu, SG detector, pentode and rectifier; but more recently the conventional five-valve superhet circuit has become as popular.

The Heater Circuit

In either case the heaters will be arranged in a series circuit, and the almost invariable respective sequences of valves in the heater chains are as shown in fig. 1, where it will be seen that the detector valves (double-diode-triodes in the superhets) are at the chassis end in both cases.

There will usually be four valves in the TRF circuit, and five in the superhet, including the rectifier in each case, and some form of ballast resistance is therefore necessary in series with the heater circuit.

One or two scale lamps are interposed at some point in the chain in most sets, but not all. Usually it is one lamp, and in most cases it will be found at one end of the chain or the other. If we regard the end connected to chassis as the "bottom" of the circuit, and the other end as the "top," then in some cases the scale lamp, or "dial lite" as some Americans choose to call it, will be at the top, but more usually it is at the bottom, between the detector valve heater and chassis. Since any resistance between the detector heater and chassis is liable to develop hum, however, the scale lamp may in some cases be connected between the upper side of the detector heater and the heater of the preceeding valve in the chain. It may or may not be shunted by a resistance.

It may be assumed that the ballast resistance will be connected between the rectifier heater and the top or positive side of the mains. There are several types of ballast resistance used in American sets.

The most popular type used is the well-known "line cord." This forms part of a three-core mains lead, although sometimes the resistance wire is wound round one of the other conductors, using it as a former, thus giving the appearance of a twin cable.

When attaching a mains plug to such a lead, the two normal conductors are connected to the two pins of the plug, and the resistance wire also goes to one of them, namely, that to which the conductor from the rectifier anode is connected. If the conductors do not bear distinctive colourings, a simple continuity test will identify them.

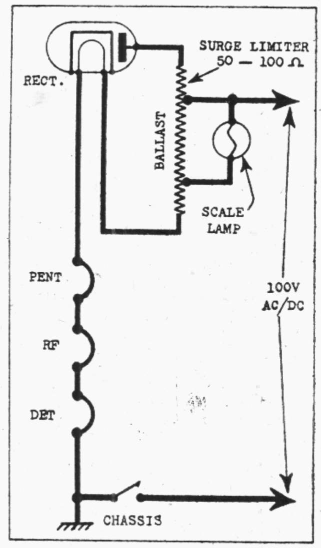

Fig. 2.—An example of the less simple arrangement, where a plug-in type of ballast tube is used. Part of the ballast resistance element is used as a surge limiter, and part as a scale lamp shunt.

Other Types of Ballast

The next type in order of popularity, especially in the more recent receivers, is the plug-in type, often miscalled a barretter. This consists of a spiral resistance element supported on mica discs and strung up and down after the manner of the filament of the old vacuum lamps. The whole assembly is mounted on an octal valve base and enclosed in either a glass or metal envelope, but it has not usually the current regulating property of the English type of barretter.

These resistance tubes are made in many types, from the simple untapped element using only two of the base pins,

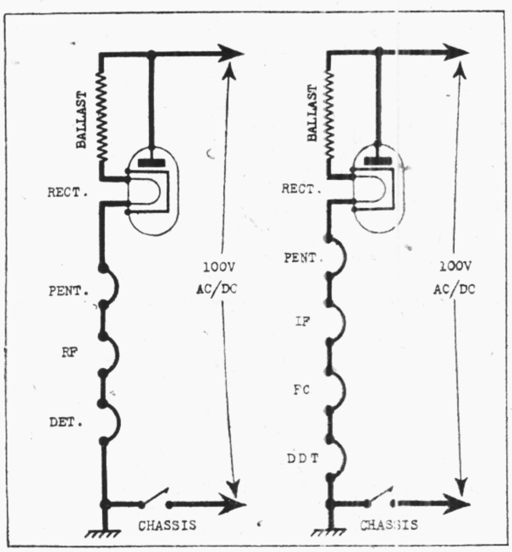

Fig. 1.—Diagrams showing the usual sequence of the valves in the heater chain of the American midget receiver.

Left: The TRF series;

Right: The superhet series.

In many cases there will also be one or more scale lamps included in the chain, as described in the text.

to comparatively complicated networks using up to six of the pins.

The more complex types provide toppings for special scale lamp connections, but essentially they all simply replace the line cord previously mentioned. They are, therefore, connected at their ends between the anode and heater respectively of the rectifier. If the rectifier anode circuit is provided with a surge-limiting resistance, the connection of the ballast resistance will be on the *mains* side of the surge limiter.

Surge Limiter Type

A departure from this generalisation, and one which might be very confusing, is found in one type of ballast tube in which one limb of the resistance element is used as a surge-limiting resistance, in series with the mains lead to the rectifier anode. Here the top mains lead would be taken to a tapping on the resistance element, where the surge limiter and ballast sections met, instead of to one end of the element. This arrangement is shown in fig. 2.

A third but less frequently encountered ballast resistance is the "Candohm" type. Most dealers will have met this type in American sets generally, but some may not recognise it by this name. It consists of a wire-wound element on some heat-resisting, insulating former in a flat metal case, and is insulated from the casing by more insulating material. The casing is about ½in. wide and varies from, say, 2in. to 6in. in length, with flat connecting tags projecting at intervals along its length.

The functions of these resistances are similar to those of the plug-in tubes, but sometimes one section of the element is isolated from the rest and used in some part of the receiver circuit, perhaps as the output valve GB resistance.

Cases have been met where the ordinary moulded carbon resistance was used as a ballast, but such cases are rare.

While on the subject of ballast resistances in general, it must be emphasised, more particularly where the line cord type is employed, that the value of the resistance is arrived at on the assumption that the mains voltage is round about 100V, and the drop required is the difference between 100V and the voltage developed across the total heater chain at the rated heater current, usually 0.3 amp. The actual mains voltage rating now adopted by the RMA of America as standard is 117V.

Where the receiver is required to operate from mains voltages in the neighbourhood of 200 V, a *second* line cord is usually employed (see fig. 3 (a)). It consists of a twin lead, in which one of the conductors is a resistance of the line cord type.

The differences between the two types of line cord, apart from their value, are that one is a three-core while the other is a two-core cable, and that while the resistance element of one carries only the heater current, the other is required to drop approximately 100 V at the total receiver current. It is evident, from queries received in *The Trader* laboratory, that many dealers confuse these two line cords.

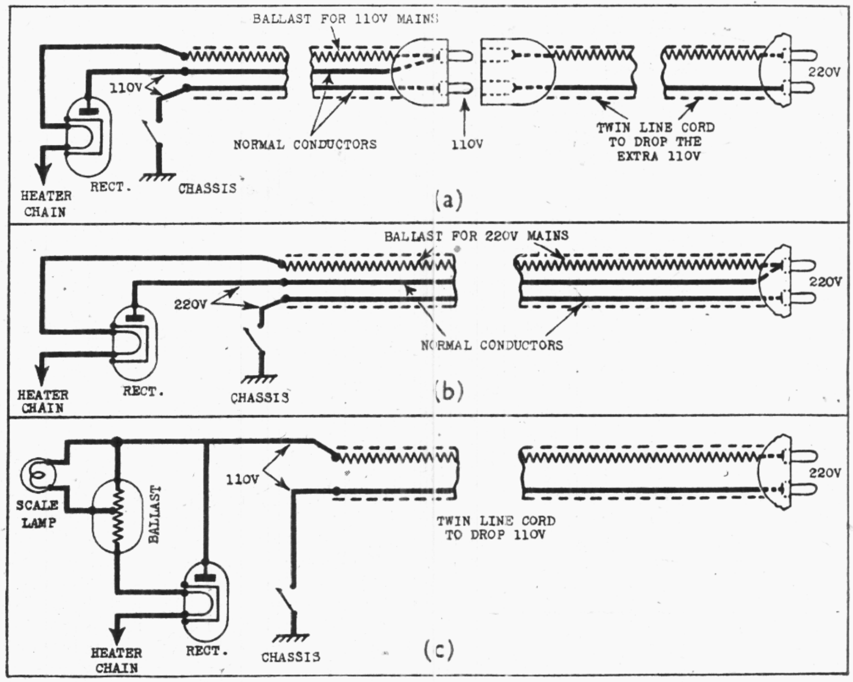

Fig. 3.—Three arrangements of line cords: (*a*) on the left the normal line cord for a 110V mains receiver. On the right is shown the additional plug-in line cord to operate from 220V mains: (*b*) line cord permanently attached to a receiver designed to operate directly from 220 V mains only. In (*c*) the cord is permanently attached for operation from 220V mains, but the receiver chassis is designed for 110V mains and includes a separate ballast tube in the heater circuit.

Value of the Line Cord

Another query that is frequently received is that concerning the value of the line cord. It is a simple matter to arrive at a suitable value by the elementary application of Ohms law. If the cord is one of the ballast type, the heater voltages must first be totalled up, including the scale lamp or lamps if included in series with the chain. If in a TRF receiver three voltages are 6+6+25+25, as is frequently the case, and the scale lamp requires 6 V., the total is then 68 V.

An average value must be taken for the mains voltage, which is usually 100-120 V, and it may be placed at 110 V. For the same reason that no main voltage adjustment is provided, namely, that the American valve heaters have a fairly wide tolerance, an average value is quite safe.

We require then 110 minus 68=42 V drop in the line cord, at 0.3 A. From Ohms law, $R=\frac{42}{0.3}=140$ ohms, which is the value required. The nearest value commercially available may be used.

The correct method of checking the heater circuit, if a fault is suspected in it, is to insert an ammeter in the heater chain and measure the current, which should be the same as the current rating of the valves. If the test is made on AC mains, an AC ammeter will, of course, be required. An AC voltmeter is useful for locating high or low resistance faults in the chain, where the current is incorrect and the ballast resistance is known to be correct.

If the line cord required is the second type, to operate a 100 V receiver from 200-240 V mains, the voltage drop may be taken as 220 minus 110, that is, 110 V, but this time the total current demanded from the rectifier (sometimes including current for a parallel-connected speaker field) must be added to the filament current.

Assuming that there is no parallel speaker field, the total anode current must be computed; we will take it as 50 mA, a fairly reasonable value.

We now require a drop of 110 V at 0.3 A + 50 mA = 0.35 A. From Ohm's law, $R=\frac{110}{0.35}=314$ ohms to the nearest whole number. Again the nearest commercial cord will do.

200 Volt Models

Cases will be met occasionally where the receiver is sold as a 200 V model. In such cases one of three methods will usually be employed: (a) two line cords joined by a two-pin plug and socket, as described above, in which the two cords can be separated to operate the receiver from 100 V mains; (b) the ballast resistance can be a single three-core line cord dropping the difference between the heater and the mains voltage as previously described for the 100 V model, but dropping a total of 220 V less the 68 V quoted in our hypothetical example, so that 220 V is applied between rectifier and chassis instead of 110 V as would be the case in (a); (c) the receiver is fitted with either a resistance tube or a resistance of the Candohm type, so that without a line cord it would operate directly from 110 V

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mains, and a permanently connected or twin-plug connected twin line cord to drop the extra 110 V is employed externally to the receiver. Fig. 3 shows diagrammatically the three arrangements described. It will be observed in the case of (b) that the HT circuit is supplied from a high voltage source, so that HT voltages in the neighbourhood of 200 V are likely to be found.

A fairly recently introduced method of connecting the scale lamp, in addition to the methods referred to earlier and shown in the diagrams in figs. 2 and 3 (c), is to connect the lamp in parallel with the upper section of the heater of a type 35Z5, 40Z5/45Z5, or 45Z5 rectifier, whose heater is tapped and brought out to a pin on the base. The arrangement is shown in Fig. 4, where it will be observed that the anode is fed from the heater tap.

The base connections of the three valves mentioned are the same in each case, and are given in *Service Sheet* 522.

Owing to the ballast action of the scale lamp on the heater, these valves are called "ballast type" rectifiers, and where they

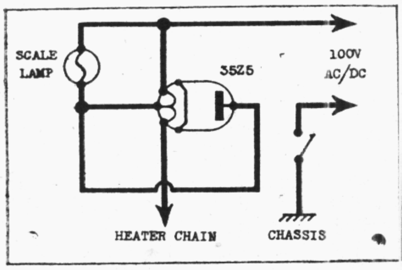

Fig. 4.—Circuit diagram of the connections to the "ballast type" rectifier, with a scale lamp shunted across part of the heater. The anode current flows through the upper section of the heater and its scale lamp.

are used it will sometimes be found that the ballast resistance is dispensed with entirely. This is because what may be termed the 0.3 A convention has been forsaken, and a new series of valves which, like the three rectifiers mentioned, have 0.15 A heaters working at higher voltages than usual has been introduced; when their heater voltages total approximately 100 V, no ballast resistance is required, and more efficient operation is thus achieved.

THE HT CIRCUIT

In most midget receivers the HT circuit is very simple; it usually consists of a thermionic rectifying valve, a smoothing choke, which may be the speaker field, in association with the usual pair of dry electrolytic condensers, from which combination runs the HT positive line. There are, as a rule, no complications in the negative side of the circuit, which consists of the chassis itself, except that the on/off switch is interposed between the chassis and one side of the mains.

Such refinements as air-cored chokes to suppress RF interference from entering the receiver circuit from the mains are dispensed with on the score of economy and compactness, two items which exercise a major influence on the design of midget receivers, but an RF by-pass condenser is almost invariably connected between the rectifier anode and chassis.

When an energised speaker is used, its field winding may or may not be employed as a smoothing choke. From the point of view of economy it may at first sight appear to be obvious that it should be so employed, but this is not necessarily true.

As has already been mentioned, midget receivers are basically 117 V receivers, and since this voltage is low for reasonably good quality loud speaker work, volts are at a premium.

On the other hand, the HT current demand by the set itself is not usually heavy enough to load the rectifier fully—and a rectifier with a larger output can be fitted if necessary anyway—so that it is quite reasonable on the score of efficiency to connect the speaker field across the HT circuit, where it increases the total HT current, but causes only a small loss of volts by increasing the load on the rectifier.

This arrangement of parallel-fed speaker field will often be found in midgets, and in some cases a separate smoothing choke may be used as well. In many cases, however, the usual position of the smoothing choke is taken by a resistance, as shown in Fig. 5. In some cases in very cheap models there is not even a resistance, so that the entire HT line smoothing is accomplished by a single reservoir condenser connected between the rectifier cathode and chassis.

Where a resistance is used in place of the smoothing inductance, it will usually be found that unsmoothed HT is fed directly from the rectifier cathode to the output valve, at least in its anode circuit, as indicated in Fig. 5. This is because the output valve anode current is large compared with that of all the other valves, and its own screen, put together, and if it were passed through the smoothing resistance the voltage drop across the resistance would be increased and might even be trebled in some cases, thereby considerably reducing the available voltage.

There is every justification for this arrangement, because it provides the maximum number of watts at the point

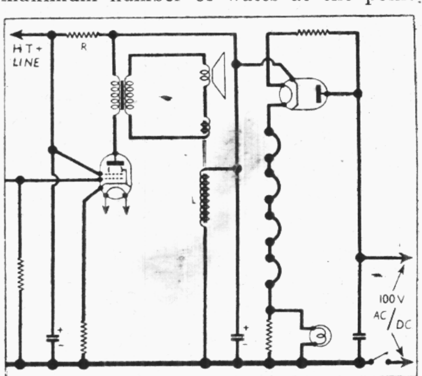

Fig. 5.—An example of the use of resistance smoothing and shunt-fed or parallel-connected speaker field. R is the smoothing resistance, and L the speaker field. A scale lamp, shunted by a resistance, is seen at the bottom of the heater chain.

where actual power is required, and the gain, which would magnify the hum voltage, is negligible. What hum there is, is

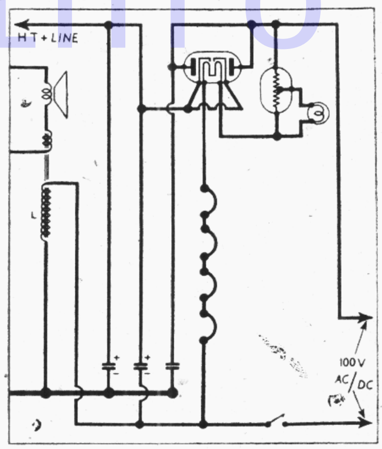

Fig. 6.—Part of the circuit of some Detrola receivers, where the speaker field is series-fed and employed as a smoothing choke in the negative side of the HT supply.

swamped by the signal, which is at its maximum here.

"Hum Bucking" Coil

In the valve circuits in earlier parts of the receiver, on the other hand, a slightly lower HT voltage can be tolerated, while any considerable amount of hum cannot, because the gain from such points onwards is high.

The foregoing remarks apply equally to cases where permanent magnet speakers are used, when the smoothing arrangements are independent of the speaker.

In most cases where an energised speaker is used, a neutralising or "hum bucking" coil is fitted as in the standard English commercial receiver, but sometimes a case will be met where the neutralising coil is dispensed with. It is difficult to see why it is not fitted, and we can only hazard a guess that the speaker does not require hum neutralisation because it is incapable of reproducing the hum frequency, which, it must be borne in mind, is 50 C/S with a half-wave rectifier on 50 C/S mains.

Two departures from the more general methods described are to be found occasionally in individual cases. One is where the speaker field is parallel fed, but has a low valued biasing resistance connected between its low potential end and chassis, as in the Firestone "Air Chief", where the value of the resistance is 125 ohms. The cathode of the output valve is returned to the junction of the resistance and the field, and so attains a positive potential with respect to the control grid, which is returned to chassis. The valve cathode current and the speaker field current combine to flow through the biasing resistance.

The other case is one where the speaker field is included in the negative HT lead to chassis instead of the positive lead as usual. This style is adopted in some Detrola receivers, and its circuit is shown in Fig. 6.

It will be seen that the field winding is in series with the mains lead to chassis, but that the bottom end of the heater circuit is returned directly to the mains lead, via the switch, and not to chassis, so that its current, which is unrectified, shall not pass through the field winding. This arrangement also requires a special electrolytic condenser block with a common positive and two separate negative outlet leads.

The Rectifying Valve

The rectifying valve circuit is fundamentally almost invariable. It is to be found in series with the upper or positive side of the mains and the HT positive line. The cathode is usually connected to the smoothing circuit, if that is in the positive side; the anode is connected directly to one side of the mains, unless one of the minor modifications referred to earlier is interposed.

The valve will have an indirectly heated cathode and will be a simple half-wave rectifier, although in many cases a valve of the voltage-doubler type may be used, but with its two independent halves (as shown in Fig. 6) connected in parallel to operate as a half-wave rectifier.

A variation of this common arrangement occurs when the rectifier is included in series with the *negative* side of the circuit, instead of the positive side, although this will not be met frequently. In such cases the connections will be reversed, so that the cathode becomes connected to the mains while the anode is connected to chassis. The smoothing arrangements might still be in the positive or negative side of the circuit.

Practical Considerations

With an inverted chassis before you, the most perplexing part of the underside very often is the rectifier valve holder and its connections. There are, as a rule, several blank tags on the holder, especially if it is of the octal type, and some of these may be used as bearer tags for connections not directly associated with the valve itself, so that an understanding of this part of the chassis, which by its nature tends to become the principal point of junction between the mains lead and the chassis proper, may frequently be helpful.

The first thing to do, of course, if it is possible, is to consult a chart showing the base connections for the type of rectifier used. If it has an octal base, it may be one of those given in *Service Sheet* 522, where several rectifier valve base connection diagrams are included.

If no such data is available, a rough sketch of the underside of the valve holder should be drawn, showing the pins, and the appropriate electrode can then be indicated against each pin as it is identified. The heater pins are usually the easiest to detect, so they should be identified first.

These connections can usually be traced by noting to which pin the line cord resistance (the white, fluffy lead as a rule) is taken; this will usually be one end of the heater. The second heater pin will almost always be connected directly to one of the heater pins on the output valve holder.

The rectifier anode is usually connected directly to one side of the mains, so that one of the rubber-covered conductors from the mains lead will be taken to it; the other rubber-covered conductor in the mains lead will go to the switch on the volume control. If there is a resistance of about 100 ohms (brown body, black tip, no dot) connected to the valve holder, it can usually be assumed that one end of it will be connected to the rectifier anode, and in such a case the rubber covered lead will not go directly to the anode pin, but to the other end of this resistance, where they will probably both be anchored to an unused tag on the holder.

If the valve happens to be of the voltage-doubler type, there may be two resistances (which are actually surge limiters), one for each anode. These will then be joined at the "mains" end to an unused tag, while their other ends will go to their respective anode tags. Where no surge limiting resistors are used, or where only one is used, the two anode tags will be joined together, as will also in any case the two cathode tags.

The cathode pin can usually be identified by the fact that a lead from the electrolytic block is connected to it, with a second lead from the speaker field, but in some cases this is difficult to identify, because the other side of the speaker field and another lead from the electrolytic block may be anchored to an unused tag. This second tag may be distinguished, however, by the fact that it is also connected to the primary of the output transformer.

Electrolytic Condenser Blocks

As in the English domestic receiver, the two HT smoothing condensers are electrolytics in a dual unit with a cardboard container, but in the midget receiver the case is of very small dimensions, so that replacement often presents a difficult problem because even the miniature blocks obtainable in this country are seldom as compact as the original it is desired to replace.

Sometimes there is just room for an English replacement beneath the chassis, but where there is not, it may be possible to fit one above the chassis just above the speaker, where there is usually a small space. Failing this, the only remedy is to fit the replacement outside the cabinet, and the most convenient place is then the back cover, sufficient length of flexible lead being left to permit the back to be removed without disconnecting the condensers. One considerable advantage in this arrangement is that the condensers are well ventilated, whereas inside the cabinet they are not.

The difficulty of replacement is sometimes aggravated by the use in the original of multiple condenser blocks, in which, in addition to the smoothing condensers, there are included one or two others which might be used as screen or cathode by-passes. Where these are encountered it is advisable to fit replacements only for the faulty sections, cutting off the discarded leads and leaving the original block in position. Before removing such condensers for test, a careful note should be made of the lead colours and their connections, as the coding is often not marked on the carton, and there may be as many as six or seven leads.

For the convenience of readers at this stage there appears in Fig. 7 a complete typical circuit diagram of the simple type of TRF three-valve (plus rectifier) midget receiver, with a single waveband covering the "Broadcast" or MW band. Below the main circuit is seen the line cord, with its two solid conductors and one resistance lead. Normally, the mains voltage would be 100-120 V. The 25Z5 rectifier shown is of the voltage-doubler type with the two sections connected in parallel. The speaker field is series connected and acts as a smoothing choke. The 0.005 μF condenser in the aerial lead is inserted as a safety device, to prevent the aerial from becoming "live" to the mains.

Service Sheet 590 will contain a description of the circuit proper, stage by stage, and will include three complete circuit diagrams of receivers that do not conform to the standard arrangement.

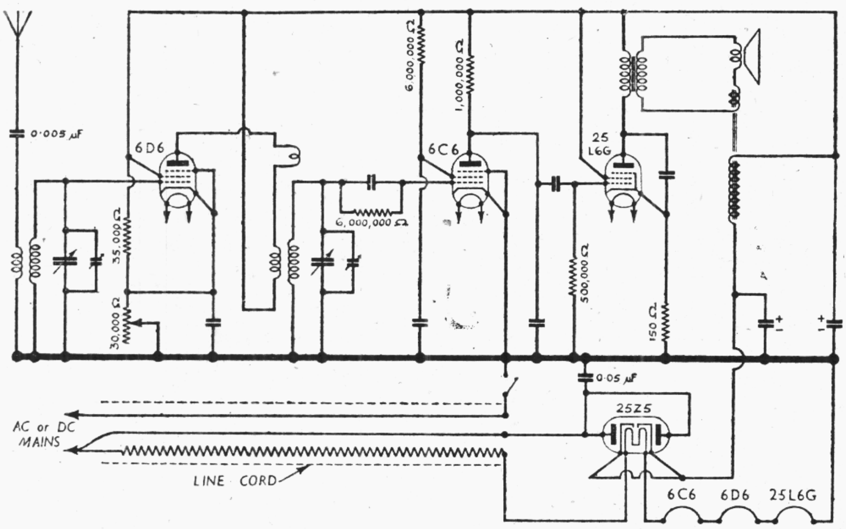

Fig. 7.—Circuit diagram showing the arrangement of a typical American midget TRF receiver. The line cord is indicated in a dotted enclosure.

Printed in Great Britain by The Cornwall Press Ltd., Paris Garden, London, S.E.1