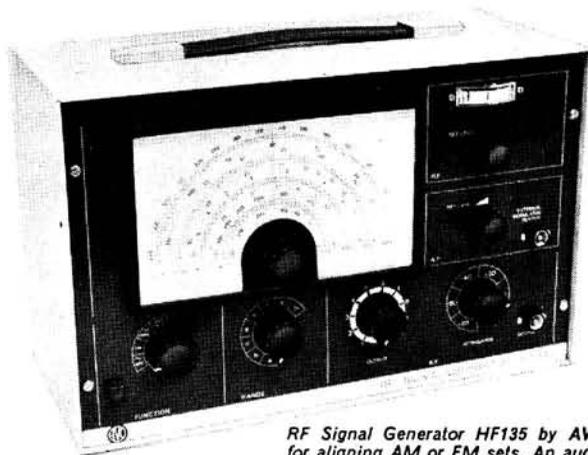


PRACTICAL WIRELESS FAULT-FINDING GUIDE

8-Page Supplement April 1976

Fault-finding in radio and similar equipment is one of the fastest ways of learning all about electronics. Component suppliers catalogues are an invaluable source of information on the characteristics of components of all kinds and such knowledge is invaluable in locating a fault quickly from the observed symptoms. In this Guide Les Lawry-Johns, a very experienced service engineer, describes the methods of servicing that he has found so successful.



RF Signal Generator HF135 by AVO for aligning AM or FM sets. An audio output is also available.

THE TOOLS

First the tools. A goodly selection of screwdrivers, among the smaller of which must be everybody's friend, the neon screwdriver. This little fellow deserves a chapter on his own, being an indicator, detective, fault tracer, a sure signaller of nearby radiated energy and a life saver. No less, but certainly more.

One must have wire cutters, and side cutters are more useful than top cutters. Pliers and tweezers of various types and sizes, files and spanners are essential and

Lots of people start off with the intention of making a living out of servicing radio sets. There are several paths to take once the basic theory has been mastered, more or less. One can specialise in, say, car radios and other car entertainment gadgets, cassette players and the like, or perhaps TVs only. Those who work for a company probably stay in the trade but some who set out to be self-employed rarely stay the course. There are several reasons for this, the main one being economic.

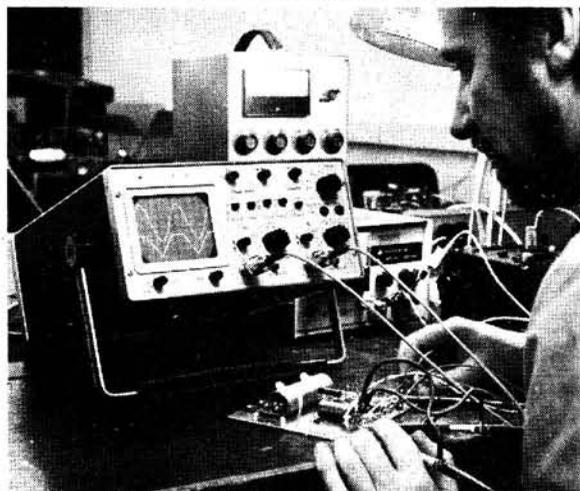
It is extremely difficult to get an adequate return for the capital laid out on component stocks and test equipment if one is repairing domestic appliances, mainly because the time involved in properly servicing each item leaves little reward when the job is completed. Therefore a lot of servicing is done on a part-time basis or as a paying 'hobby' with the accent on the hobby aspect rather than on the paying!

We have to assume that the reader has a basic knowledge of electronics and some idea how radios and the like function. The chief requirement after this is patience and a genuine desire to do the job, and to do it properly.



The Advance 'Alpha' digital multimeter takes up little bench space.

FAULT-FINDING GUIDE



Shown here is the Advance Electronics low-cost dual-trace OS240 oscilloscope.

included in the latter should be the single-ended type with a handle, known as a nut spinner, in at least 6BA and 4BA sizes and with the close metric relatives. A comprehensive set of trimming tools, which can be purchased as a kit; at least two soldering irons, for delicate and heavy work. A reel of 18SWG (1.2mm) resin-cored solder and some means of removing solder, preferably desoldering braid which is copper braiding impregnated with resin flux. It draws the solder away from a heated joint allowing a component to be removed. Alternatively, some form of vacuum pump, possibly combined with a soldering iron.

A small torch which can be held in the mouth, if need be, and a magnifying glass are essential items whatever your age and eyesight! Next, the handmaiden of all electrical work, a decent multi-meter, preferably two. One should be a good quality meter for bench work, the other a smaller, less expensive, knock-about type for general use and back-up for use with the other, as one often wants to make two readings at the same time. Apart from this it often happens that the main meter is out of action for some reason, and at the most inconvenient time. Other instruments such as oscilloscopes, signal generators, bridges and the like can be regarded as highly desirable equipment to be purchased when funds allow.

MULTIMETERS

The multi-meter should impose as little loading as possible on the circuit being tested otherwise the voltage present will be different when the meter is applied from what it is normally. A voltmeter is operated by current drawn from the circuit being tested and this current must be as small as possible. Most meters are marked on the front with their sensitivity and a figure of 20 000 ohms-per-volt (OPV) should be the minimum requirement. It should also have some form of cut-out or overload protection. The man who hasn't taken a reading with the meter set to the wrong range hasn't yet been born!

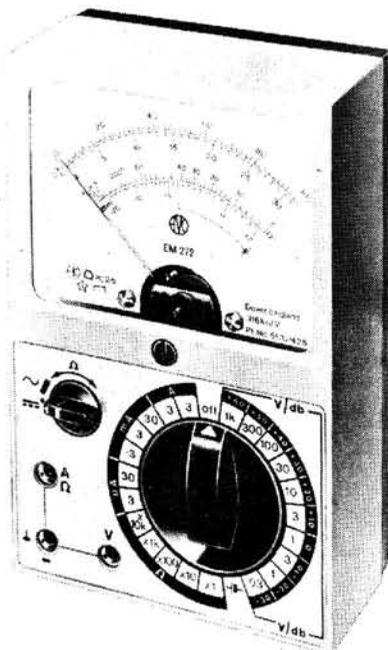
As well as reading voltage, current and resistance the meter can also be used to apply tests to circuits and components since, when switched to the resistance range,

a **negative** voltage appears at the positive test probe and a **positive** one at the negative probe. This enables a check of the approximate characteristics of capacitors, transistors, diodes and the like to be made. After voltage readings, this facility is probably one of the most valuable assets of a multi-meter so we will spend a little time on this subject, later on. However, we must continue with our "tools of the trade" requirements.

There are a great many aerosols (sprayers, squirters etc.) on the market at the present time, each of which has its own merits. Most engineers would select two, a contact-cleaner lubricant, which does not attack plastics, for cleaning switches, volume controls and the like, and a cooling agent or freezer. The value of these two can hardly be exaggerated. Whilst the former has always been accepted as a must, the choice of the latter has been dictated by experience over the last few years. Large numbers of small components grouped on a board can present a problem when tracing intermittent faults or where any one of a number of transistors in, say, an audio stage can be responsible for upsetting the operation of the others. A judicious squirt of freezer has solved many such baffling problems and a hair drier has its uses too!

STARTING

So here we are, with a few tools of the trade and prepared to do battle. However, it is one thing to identify a faulty component, when all you have to do then is to obtain a replacement, but all too often we can only suspect and it is essential then to make a substitution check. Resistors can usually be tested and passed as fit or thrown out, but capacitors present a different problem. They can leak, partially or completely dry up, become open circuit or



The new AVO Electronic Multimeter EM272 provides 39 ranges in spite of the simplicity of its appearance.

AULT-FINDING GUIDE



In use here is the Advance DMM7 digital multimeter, a new 3½-digit 5-function instrument.

develop a short sometimes accompanied by heat. Therefore a goodly number of capacitors of various types, capacity and voltage rating must be held in stock.

Voltage rating is important from two aspects. Obviously a capacitor rated at, say, 12V would not be put across a 25V line as the voltage rating marked on the component must not be exceeded, but it is often thought that a capacitor marked, say, 100V can be used in any circuit where the voltage is less than this. Usually this is quite true, but there are exceptions. If the capacitor is electrolytic it requires a certain polarising voltage for it to work efficiently. In some circuits the voltage is very low, say about 4V, and a replacement in such a position should be rated at not much more than 6V or whatever voltage is marked on the defective item.

Diodes are another item which can be checked with a meter, within limits, and a few of the more common types in stock will usually suffice. Bridge rectifiers are commonly used in mains powered equipment and they often give trouble. One is well advised to keep a couple to hand and two types usually suffice, the BY164 for operation up to 40V and the BY176 for higher voltages. Four silicon diodes



A new product from Advance is the J4 signal generator, with sine or square wave outputs.

can be used in place of a bridge and indeed this type of supply will often be found but where a single block bridge is encountered it is often inconvenient to fit four diodes in its place.

The choice of separate power diodes is large but one cannot go far wrong with a few BY142 (BY127 with a smaller package). Voltage regulator diodes (zeners) appear in all types of equipment and one would be very hard put to try to anticipate what is going to be required if many makes and models of radio are tackled. It is no hardship to order the right components at the right time, if one knows in advance the type of equipment which is to be serviced, but if this is not known the stock list could be endless.

The same can be said about transistors and the position is more complicated as the age of the set to be serviced usually dictates the type of device used. The following is a list of transistors which ought to be kept in stock for the general servicing of audio equipment, radios, car radios etc.

AF115	AC187K	BC131	BC186
AF117	AC188K	BC132	BC194
AC127	AD149	BC147	BC195
AC128	AD161	BC149	BC196
AC187	AD162	BC157	BFX88
AC188	BC109	BC159	BFY50

From this modest list one can often find a suitable replacement for the more difficult-to-obtain types and some which are not marked. The latter present a minor problem but this is about all.

IDENTIFYING TRANSISTORS

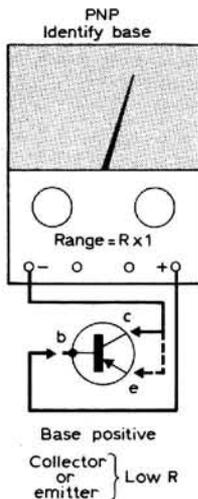
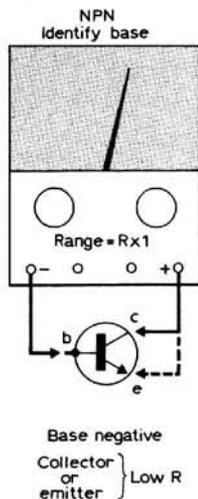
Most transistors have only three leadouts, these being emitter, base and collector. They will belong to one of two basic constructions, NPN (neg-pos-neg) or PNP (pos-neg-pos), so this is the first check to make and it is a very easy one using the ordinary multi-meter. It must be appreciated that when the meter is switched to the 'ohms' range it is battery operated and that the positive (+), or red, probe will be on the negative side of the battery with the negative (-), or black, probe at a positive potential. If the red probe of the meter is applied to the base of a PNP transistor a low reading will be shown when the black probe is touched to the collector or the emitter. On the 'ohms' scale this will look like something between 10Ω and 50Ω depending upon the transistor type and the meter.

If only one reading can be obtained note to which leadout the black probe is applied and assume this is the base of an NPN transistor, when the red probe can be applied to the other two to obtain the low reading. If there is no low reading, the red probe should be applied to another leadout on the assumption that the device is a PNP after all, but that you didn't get the base lead in the first place.

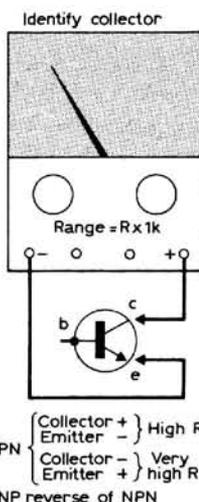
Now that the base has been identified and the device established as a PNP or an NPN, it is necessary to identify the collector and the emitter, remembering that we are supposedly dealing with a good transistor and not one with a short or open circuit.

Switch the meter to the high resistance range, and, leaving the base free, connect the probes to the other two.

FAULT-FINDING GUIDE



W171



Diagrams to show the method of using a multimeter to identify the leadout connections of NPN or PNP transistors. As explained in the text the polarity of the test prods of most meters is the opposite of that indicated by the colour of the prods. It is best to check this point before using the meter on transistors or electrolytic capacitors.

If the transistor is an NPN and a high resistance is recorded, the negative (black) lead is connected to the collector and the positive (red) lead to the emitter. Reversing the probes should then give a low reading.

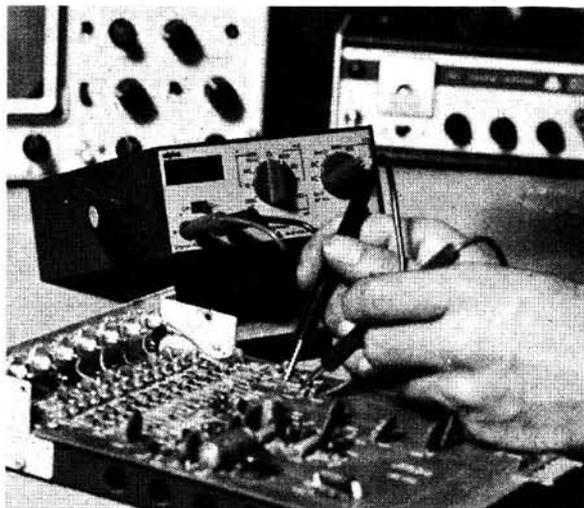
If the transistor is a PNP (we have already established this in the first test, so don't get confused) the readings will be reversed, high reading positive to collector, lower reading negative to collector. A further test can be made on the transistor. Connect as above, negative lead to collector, positive to emitter, if NPN, (reverse for PNP) and note the high reading. Place a finger on the collector and base leads and the reading should drop, showing that the transistor is "turned on". The actual reading will depend upon the current gain of the transistor and the resistance of the skin of the finger. What good is this, you may ask? Well, it does enable you to make a comparison check against a known transistor and so, very roughly, identify the current gain.

Diodes can be checked in a similar way but of course there are only two connections to make. Positive lead to

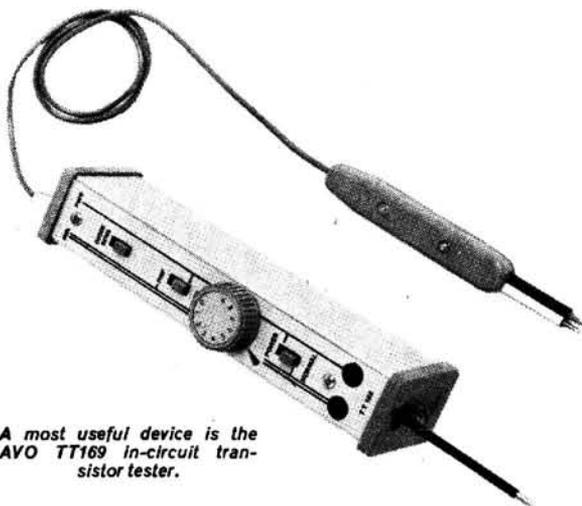
cathode (+) gives a low reading, while negative lead to anode gives a high reading. A little practice with known good transistors and diodes will show the readings which can be expected. These tests can be used on components in circuit provided the associated circuitry is taken into consideration, particularly where transistors are inter-connected, say output transistors with drivers across them, etc.

COMPONENT CHECKS

Capacitors can be checked roughly with an ohmmeter switched to the highest resistance range. When the test leads are first applied to a discharged capacitor, the applied voltage will cause the charging current to deflect the meter sharply according to the capacity, the reading going back towards infinity as the capacitor is charged. If the capacitor is leaky, current will continue to flow and a reading



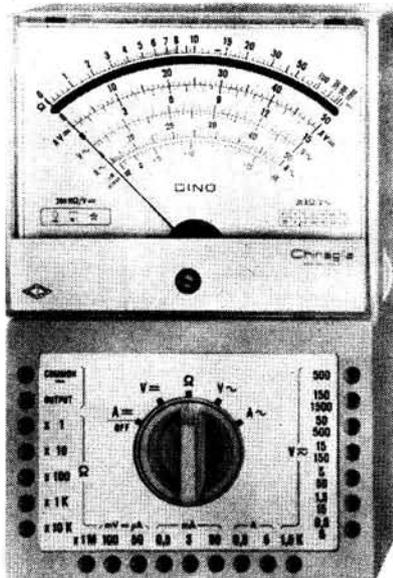
Another useful bench instrument is the Advance 'Alpha' digital multimeter, being used here to make resistance checks on a circuit board.



A most useful device is the AVO TT169 in-circuit transistor tester.

FAULT-FINDING GUIDE

will be maintained. This is to be expected with high value electrolytics as the meter voltage is insufficient to complete the sealing process. Once again a little practice will show what is to be expected. Very little indication, except leakage, will be shown on capacitors less than say 50nF but the tests are more valuable as the capacity increases. Don't forget, electrolytics require the negative probe to be applied to the positive tag of the electrolytic in order to get the right polarity for the charging voltage.



The Dino is the latest electronic multimeter from Chinaglia, 200k Ω OPV on DC and 20k Ω OPV on AC.

Inductors, transformers and the like can be checked for continuity and resistance. The presence of shorted turns can only be assumed if the resistance reading is much lower than that specified.

When a resistor is suspected of being faulty, first look at its appearance. If the colours are clear and bright and the resistor has a fairly low value the chances are that it will be serviceable. If it has a higher value, say over 100k Ω , it could look right but the value may have increased, particularly if used in a position where it is passing a fair current. Checking depends upon the circuitry, for if it is associated with other resistors or transistors, a direct reading may be of little use and one end may have to be lifted by unsoldering in order to check it out of circuit.

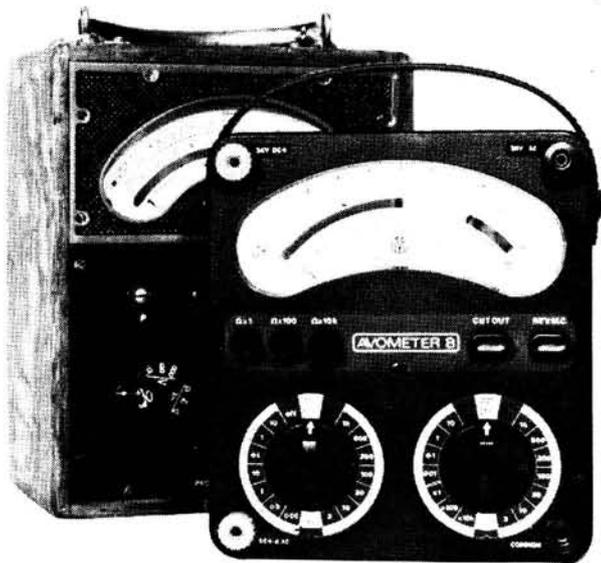
If the colours are not clear or if the resistor presents a well-worn look, replace it, even if it reads right, in order to save probable trouble later. This particularly applies to the low value resistors associated with output transistors usually about 2 Ω or so). If a high value resistor is suspected it can often be checked with the receiver switched on by connecting a voltmeter across it, on a high range. The recorded voltage drop being of less importance than the effect of the resistance of the meter which shunts the suspect resistor and thus, to an extent, takes its place. Care must be exercised when using this dodge in pre-amplifier stages where the meter resistance can upset the base current of a transistor if the associated resistor values are high.

SHORT CUTS

There are no substitutes for routine tests, checking supply and stage voltages in logical sequence, injecting test signals to identify the working and the faulty stages. To do this one must be able to think 'electrically', and while this comes easy to some, it is hard work for others and only comes with time. Following certain guide lines the fault will always reveal itself provided enough time is spent on the problem. However, as one becomes used to the type of equipment being serviced a pattern usually emerges which enables a short cut to be made across the routine tests and thus head straight for the source of the trouble, using eyes and ears and sometimes the sense of smell and of touch. A dry joint (one which has not been properly soldered in the first place) can often be seen, rather than traced, by its discoloured and 'powdery' appearance.

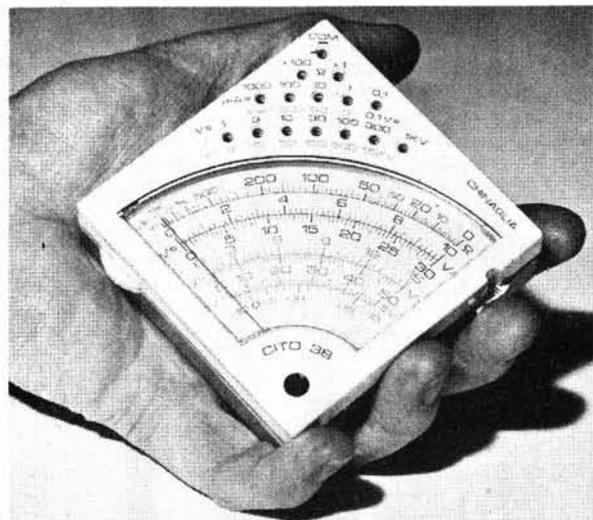
Sound distortion can be caused by many things but after a while the ears will unerringly identify the sound of a rubbing speech coil in a loudspeaker as opposed to a similar noise caused, say, by the output transistors being mismatched. The smell of some types of overloaded or faulty rectifiers immediately proclaims a defective one, whilst touching a hot transistor, apart from being painful, can cool it down and allow it to begin working for a brief period.

Some makes of printed circuit board are more liable to develop hairline cracks than others. Some types of capacitor are far more likely to fail than others. Indeed, we could go so far as to say that where certain types of capacitor are found fitted, we do not bother to check them since they are so very rarely at fault, whilst others are the first suspects and pounced on immediately. Some transistor types are more likely to fail than others. This sort of fault can be repeated over and over again and, whilst it makes life



The Model 8 Mk 5 general purpose multi-range meter is the latest in a very long line of multimeters from AVO. An early version of the meter appears in the background.

FAULT-FINDING GUIDE



Smallest of the Chinaglia range is the Cito multimeter but it still manages to provide 14 ranges on six coloured scales.

a trifle easier for the experienced, the inexperienced person has no option but to employ routine tests and finally arrive at the same conclusion, having spent a considerable amount of time in the process. If in doubt, ask someone who knows and thus profit from their experience.

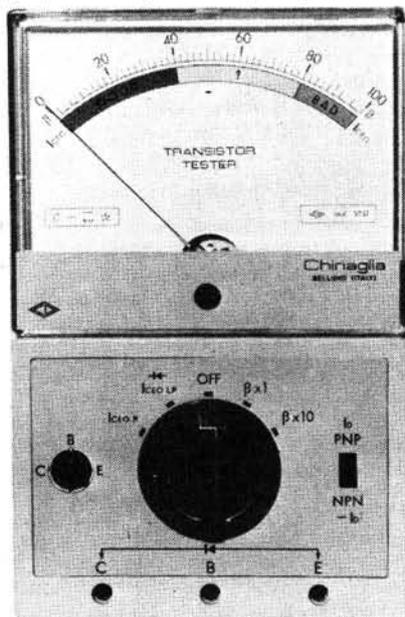
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PRACTICAL ASPECTS

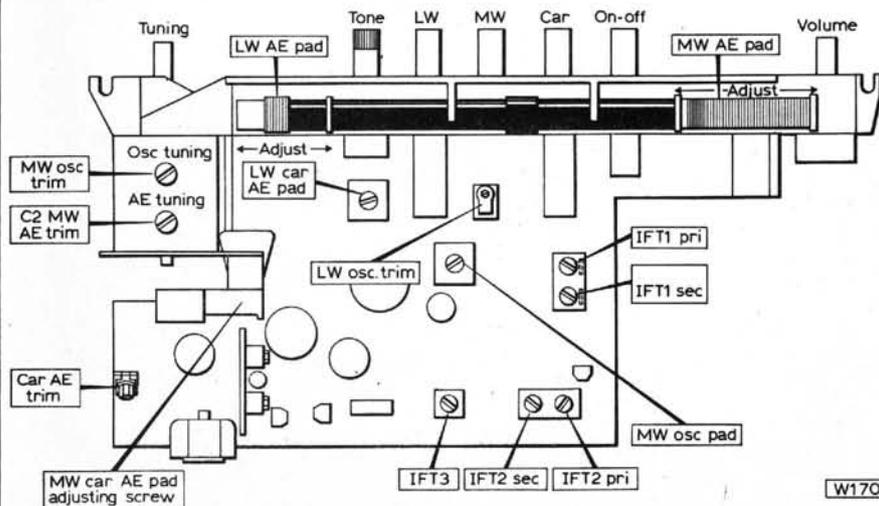
We gave a short list of the items needed to service the simplest of appliances but there are others to consider. A circuit with a layout diagram is an absolute must if the appliance is not well known. Fortunately, in addition to the maker's service information which is the best source of reference, there are volumes of service data in book form available which condense this information, so that it is possible to build up a library of information which is readily to hand and indexed.

Not all appliances are complete when they are received for repair. For example, a car radio will need a 12V supply and most likely a loudspeaker. This is not too bad since most car radios use a 3Ω speaker, although more recent imports use 8Ω in some cases. However, it is often inconvenient to remove sited loudspeakers when a unit audio goes wrong, assuming that the speakers are not at fault, so it is necessary to have suitable speakers for test purposes. These are frequently 8Ω, but not always, by any means. So be prepared to add series resistors to make up the required loading or keep a goodly selection of loudspeakers!

Before we drop this subject, one further point. There are always power amplifiers requiring repair. If you do

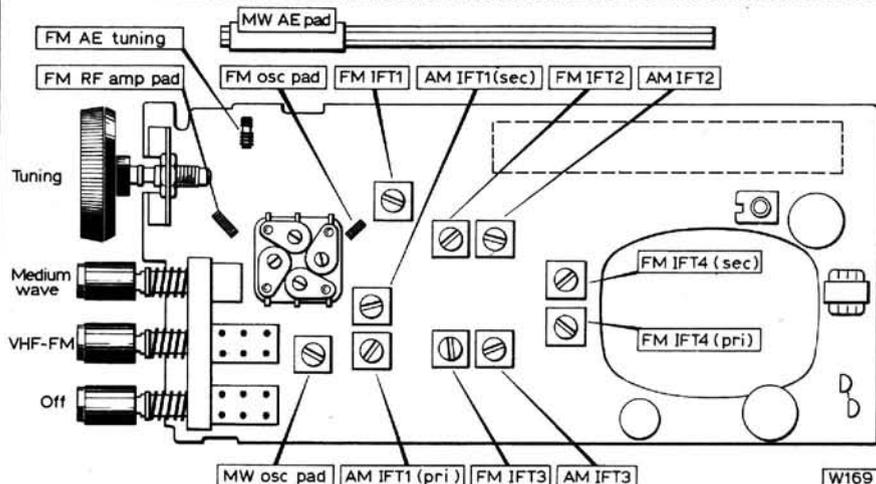


The Chinaglia transistor tester provides a Good-Bad indication plus leakage and β , using internal batteries. Test leads can be fitted for checking external circuits or devices.



Service sheets provide information for fault-finding and the alignment of receivers. This particular layout shows the location of the components which may require adjustment when aligning the Marconi 4173 MW and LW receiver.

FAULT-FINDING GUIDE



The Marconi 4184 receiver also incorporates the VHF(FM) range so the number of adjustments needed for a complete alignment is increased, as shown here.

take on one of these and repair it, have a care for your test loudspeaker. To touch the input socket with the volume control well up is to ask the amplifier to deliver full power into what may be a small loudspeaker, the probable result being a wisp of smoke from the speech coil which, if it survives intact, will never be the same shape again!

OTHER TEST GEAR

Whilst our multimeter enables us to check voltages, measure current and take resistance readings, plus a few other things, no serious service work can be carried out without the aid of other instruments, the first of which is a signal generator. This enables us to inject signals of known frequency and level and thus to check the alignment and response of the equipment under test.

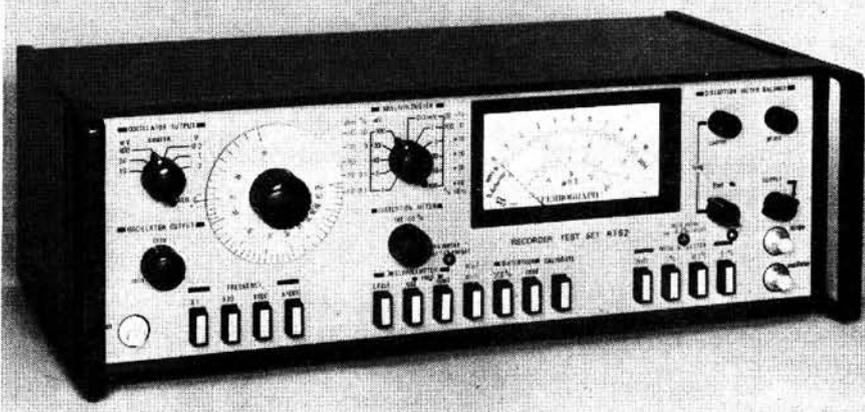
Let us take an average radio set. Considering the medium wave band only, signals from say 600kHz to 1.5MHz have to be selected and amplified. Since there are several stages of amplification, it is clearly not convenient to tune each stage to each frequency separately. What is required is for all signals to be converted to a common frequency which can then be fixed tuned. This is known as

the IF, or intermediate frequency, which for AM reception is usually fixed at about 470kHz. Some imported radios have a lower IF, 455kHz, which is the reason for the annoying whistle sometimes experienced adjacent to stations operating around 908kHz. Therefore the generator will have to cover this band of frequencies plus all RF frequencies likely to be covered by the receiver.

This will enable us to check the tuning of the aerial coils, the oscillator and the IFs. If these coil cores and trimmers are not accurately adjusted the receiver cannot give of its best. The signal generator provides a means of doing this, and much more, since we can now inject signals into various stages of the receiver and thus locate the stage which is not functioning correctly. The wobblers is a variation of the signal generator, which we will not consider here, but which is essential for many kinds of accurate alignment.

An oscilloscope enables us to "see" into a circuit. The signals are amplified and appear as a trace on a screen so that the effect of each stage can be seen and adjusted, if necessary, to the required amplitude or waveform. It therefore enables us to see where signals are lost or become distorted.

The Ferrograph Test Set RTS2 from Wayne Kerr combines many of the facilities needed for checking the performance of recorders, amplifiers and other audio equipment. Included are an audio oscillator, distortion meter and AF millivoltmeter.



FAULT-FINDING GUIDE

ALIGNMENT

Having mentioned these two valuable aids, let us immediately correct any misconception. In everyday radio repairs they are rarely needed. If the IF alignment has not been disturbed, do not touch it! If it has, it probably needs only a "tweek" to restore normal reception. Note which core or trimmer has been disturbed (wax or seal broken) and bring this, or them, into alignment with the other circuits. If the oscillator and aerial trimmers have been altered, switch to medium waves, set dial to about 1200kHz (250m) and set the oscillator trimmer to bring in Radio 1 (or any other frequency which is known to correspond to a particular station at this end of the dial) reset to around 1500kHz and trim the aerial trimmer. Retune to the lower end of the dial, to say Radio 3 on 647kHz, (this is the low end from a frequency point of view) with the core of the oscillator coil, appreciating the fact that this is going to upset the previous trimmer setting at the HF end which will have to be done again. Do this a couple of times until satisfactory tracking is obtained.

If a ferrite rod aerial is used adjust the medium wave winding on the rod for best reception on about 650kHz finally trimming the aerial trimmer, back on about 1500kHz. Leaving these settings untouched, switch to LW, tuning to 200kHz, or 1500 metres, then adjusting the long wave trimmer to bring in Radio 2, and setting the LW aerial trimmer to peak the signal, or adjusting the LW coil on the ferrite rod.

At this point any disturbance of the IFs can be corrected. If correct tracking cannot be achieved the IFs have probably been more seriously disturbed than was thought and the signal generator can then be brought out of cold store,

Photographs were kindly supplied by the following companies to whom all queries on the instruments illustrated should be addressed.

Wayne Kerr, Durban Road, South Bersted, Bognor Regis, Sussex PO22 9RL.

AVO Ltd., Archcliffe Road, Dover, Kent CT17 9EN.

Chinaglia Ltd., 19 Mulberry Walk, London SW3 6DZ.

Advance Electronics Ltd., through Peter Bush, Bush Steadman and Partners, Saffron Walden, Essex.

set to the required IF (as marked on the set, or in the service information) and loosely coupled with a single turn of wire around the ferrite rod. With the set tuned to the low frequency end of the medium wave band, about 600kHz, increase the signal input until the modulating tone can be heard, adjusting the IF coil cores to peak and gradually reducing the signal input from the generator to the minimum, to prevent the AGC coming into action. Repeat the RF tuning procedure.

SNAGS!

Simple enough, isn't it? So where's the snag? Well, you see, we've only mentioned some of the procedure for AM sets. Two examples of the kind of component layout to be expected are shown, one a long and medium wave design as used in the Marconi 4173. Notice that the tuning adjustment for the low frequency end of the dial is called 'padding' and the high frequency adjustment is called 'trimming'.

The snag arises when there are many coil cans and lots of trimmers! The rule here is not to do anything unless you know the exact purpose of each adjustment. Otherwise you may be disturbing something which was previously correct and this is not the idea at all. Also shown is the layout of another Thorn group model, this time a Marconi 3183. Here we see the IF coil cans clearly marked AM and FM. These will not be marked as such in the actual set and therefore no coil cores should be disturbed unless such a diagram is available. Even then adjustment of the FM coils requires the use at least of an FM signal generator, preferably with 'wobbulator' and oscilloscope, in order to obtain the desired response curves.

The object of all this is to preach the sermon loud and clear. Do not touch what is not fully understood and attend only to that which really requires attention.

THE GENERAL THEME OF THE FAULT-FINDING GUIDE WILL BE CONTINUED IN THE JUNE ISSUE OF PRACTICAL WIRELESS DUE OUT ON 7 MAY.

YOU WILL WANT OUR PW RADIO SERVICING CHART!

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of PW-Out on 2nd. April**

**DOUBLE-SIDED! Use the front of the chart to
localise the fault — Turn the chart over for an
analysis of the problems!**