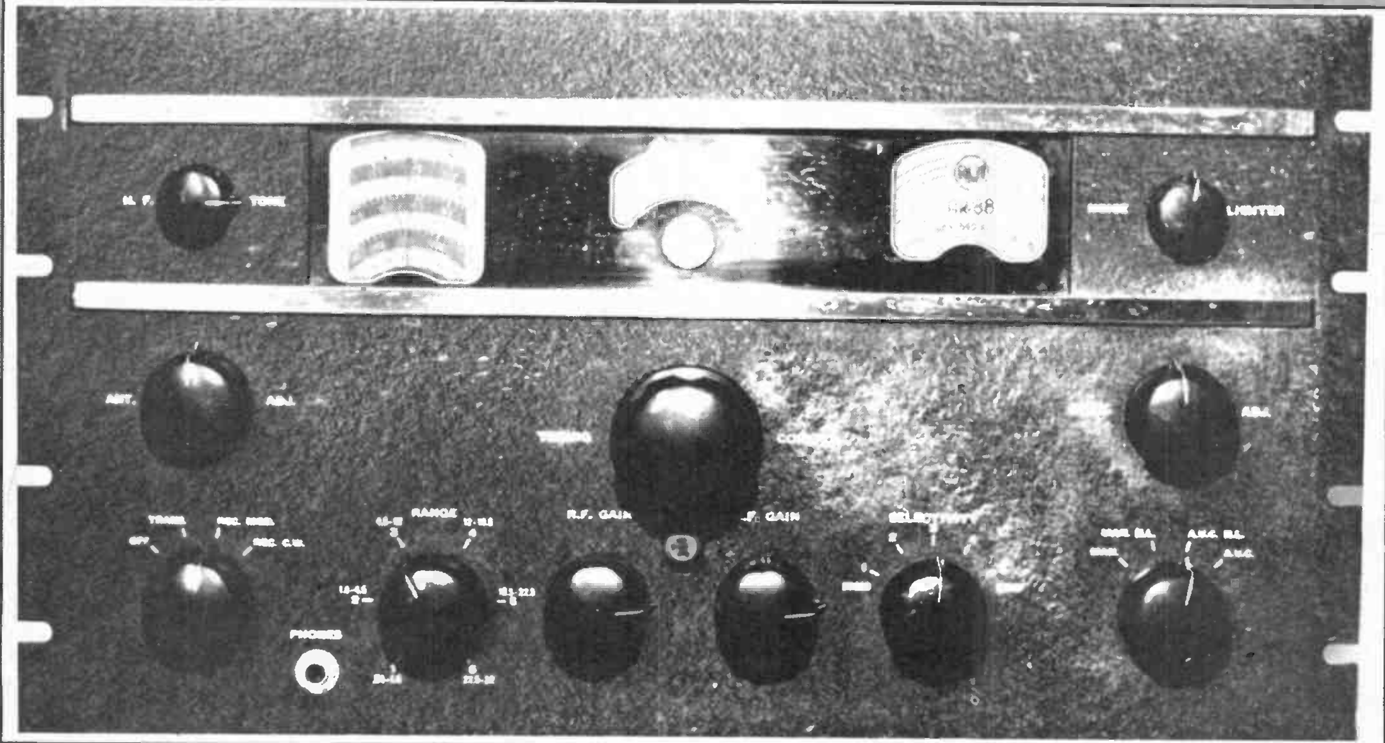
THE AR 88



This receiver is still fairly widely available on the secondhand market from near-mint condition to sheer grot – depending upon the previous owner. For a modest sum (about £50) an AR88 can be acquired in excellent condition.

You should aim for one which has not been modified. The construction of the receiver is of a very high standard and unless any modifications have been executed to a similar standard and properly documented they are likely to detract from its performance and reliability. The AR88 is rather like the VW Beetle – it tends to go on for ever!

The AR88 has a long history, starting life in the late 30s as a general coverage receiver but intended also for amateur use (hence the AR). This version is not often seen on the market; it covers the range 550kHz to 32MHz and is fitted with an S meter. However do not confuse it with one which has had an S meter added!

The 1939-45 war and the need for reliable communication receivers resulted in large-scale production of

First produced in the 1930s, the RCA AR88 still commands a big respect from amateurs. Full description by Bob Henly, C.Eng., MIERE, G31HR.

the AR88 in various forms including a CR series (not to be confused with the Marconi CR 100, etc). Two models are generally available now. These are the **AR88LF** and the **AR88D**

The main difference between these two models is that the AR88LF has a lower intermediate frequency and a low frequency tuning range 75 to 150kHz. The AR88D is better suited to amateur use and this article will therefore concentrate on that model.

First, let us see what it is. The AR88 is a single-conversion super-het with a total complement of 14 valves (those ancient glass things referred to in a recent article). The receiver is shown in block-schematic form in fig. 1. It comprises two tuned RF stages and 3 IF stages. The two tuned RF stages are essential in view of the relatively low intermediate frequency of 455kHz in order to reduce its response to second-channel interference. The coverage is continuous from 530kHz to 32MHz in six over-lapping ranges.

The two RF amplifier stages use 6SG7 valves and are designed to provide only sufficient gain ahead of mixer to give the required signal-to-noise ratio. The principle purpose of the RF stages is to provide selectivity ahead of the mixer in order to reduce second-channel responses. This is its main weakness; image rejection of 500kHz is about 120dB but at 30MHz it falls to about 40dB. Fig. 2 shows the manufacturer's performance figures for sensitivity and image rejection. Although current practice would probably use much less gain ahead of the mixer in the interest of cross-modulation performance the AR88 in fact acquits itself very well when compared with many modern equipments on this score.

The mixer is a 6SA7 and the local oscillator is a 6J5. The supply to the local oscillator and the BFO is stabilised at 150 volts by a VR150/30. The Intermediate Frequency (IF) stages comprise a single crystal bridge filter followed by a three-stage tuned amplifier using 6SG7s. The inter-stage coupling circuits between first and second, and between second and third stages, each use four tuned circuits. These have variable coupling links which together with similar links in the crystal filter circuit enable IF bandwidths between 400Hz and 6kHz to be switch-selected. In addition, two further positions of the selectivity switch give 'fidelity' bandwidths. The IF bandwidths are summarised in fig. 3.

The second detector is of the diode envelope type using half of a 6H6. The second half of this valve provides carrier-derived AVC which is applied to the RF stages and the first and second IF stages. AVC is selected by a front-panel switch and a novel feature is that the RF gain control which also operates on the RF stages and the first two IF stages alters the AVC delay.

A 6J5 is used as a Beat-Frequency Oscillator (BFO) for the reception of CW. The anode supply is stablished at 150 volts. The frequency is adjustable from the front panel over a range of approximately +/– 3kHz about the IF. Output from the BFO is injected at the grid of the third IF amplifier ensuring a good injection level. A second 6H6 is used as a peak noise limiter with the clipping level adjustable from the front panel.

Audio output is provided by a two-stage amplifier comprising a 6SJ7 followed by a 6K6 output stage which is designed to deliver 2.5 watts into either a 2.5 ohm or 600 ohm load. The front panel jack provides approximately 10mW into 20,000 ohms from an additional winding on the output transformer. The integral power supply – which contributes a large part of the weight – operates from either 110 or 230 volt AC and uses a 5Y3 rectifier. A socket on the rear apron is provided for operation from external power supplies.

Both rack and table mounted versions can be found. It is built like the proverbial battle ship; overall dimensions are 19.25in × 11.0in × 19.25in deep and it weighs about 80 lb. Both mechanically and electronically it is very stable and although its physical size may be rather daunting it represents a very good buy.

The panel layout and location of the controls is shown in fig. 4. The central feature is the tuning control and the two tuning dials. The main

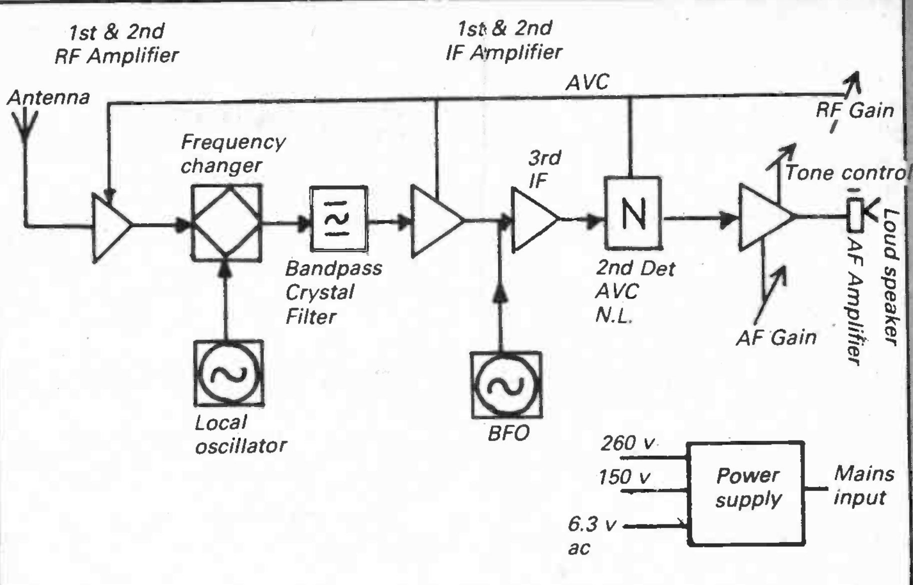


Fig. 1 Receiver diagram

Band No.	Megacycles	Sensitivity in Microvolts for 0.5 watt	Antenna Input in Microvolts for 6 DB Signal-Noise Ratio	Antenna Input in Microvolts for 20 DB Signal-Noise Ratio	Image Rate
1	.6	.5	.9	4.6	$>10^6$
	1.0	.9	1.4	8.0	
	1.5	1.0	2.2	12.0	10^6
2	1.7	.6	1.0	5.0	$2.4x10^5$
	3.0	.6	.95	4.8	
	4.3	.6	.9	4.5	$14.5x10^3$
3	4.6	.8	1.3	8.0	$6x10^4$
	8.0	.8	1.2	6.8	
	11.5	.7	1.1	6.0	$2x10^3$
4	12.1	1.2	1.3	6.6	$4x10^3$
	16.4	.7	1.2	7.0	$1.5x10^3$
5	16.4	1.3	1.3	7.0	10^3
	22.5	.8	1.4	8.0	400
6	22.5	2.5	1.5	8.0	400
	28.0	1.2	1.3	7.0	200

I-F rejection at 600 kc is 100,000.

Fig. 2 Performance data

dial on the left comprises seven concentric scales: one for each range and an inner logging scale. Calibration is in MHz except on range 1 where it is in kHz. The logging scale comprises a number of numbered segments each representing one revolution of the vernier scale. The vernier dial occupies the centre of the panel and has a single scale graduated from 0 to 100. The two dials are coupled together, to the tuning control and to the main tuning capacitor by a train of split gears which result in a very smooth 'feel' with zero discernible 'backlash'. This is probably one of the most attractive features of this receiver and is one item which requires careful inspection before purchase – of which more anon.

How well does it perform under today's conditions? The answer (in the author's opinion) is: quite well. As a CW receiver it is superb and the crystal filter is quite adequate for most situations. The addition of an audio filter such as Datong FL1 or FL2 more than compensates for any inadequacy. Its performance in the presence of strong adjacent-channel signals is very good – 7MHz is a good test of any receiver and the AR88 can certainly hold its own. Its main weakness is on SSB. This weakness is due to three main things. Firstly the tuning rate on all amateur bands is a little too high to make the initial acquisition of a SSB signal easy. Secondly the IF selectivity curve is not sufficiently steep-sided to resolve SSB to its best advantage. Thirdly the BFO is not preset for upper and lower side-band. The first is overcome to a great extent by practice and some owners have fitted an additional, out-board epicyclic drive to the main tuning control to slow it down. The IF response can be modified a little by careful alignment (of which more later) or the filter can be replaced by a more suitable type, but this is major surgery. As far as the BFO is concerned a variable control is invaluable for CW and therefore it is necessary to determine the two settings for upper and lower sideband respectively with a little patience and record them for future use by two discrete marks on the front panel.

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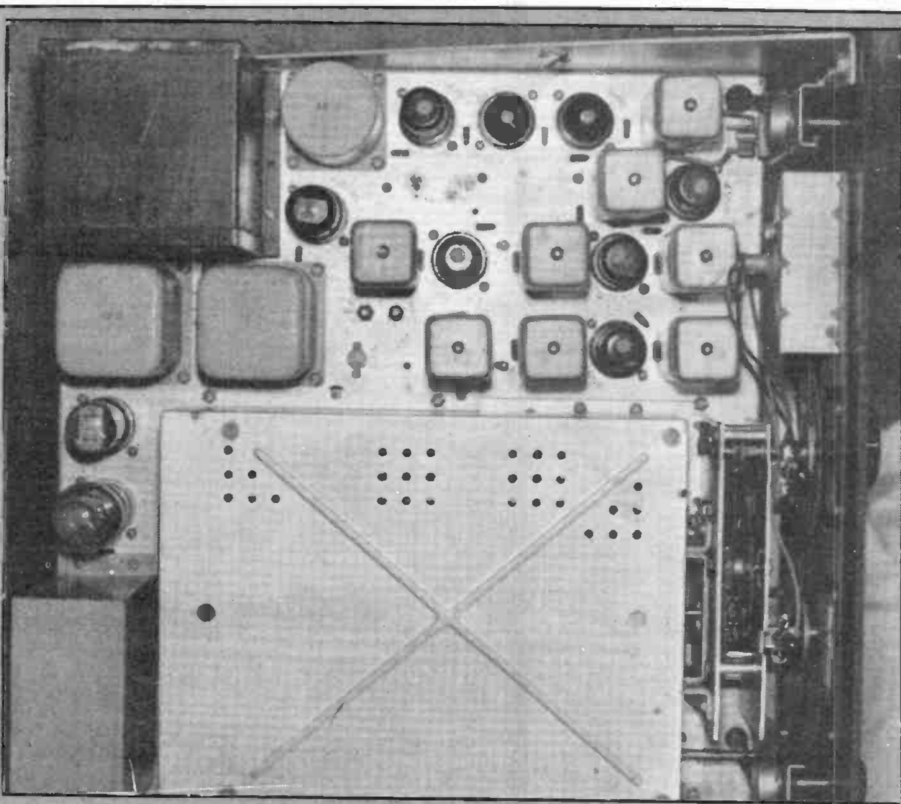
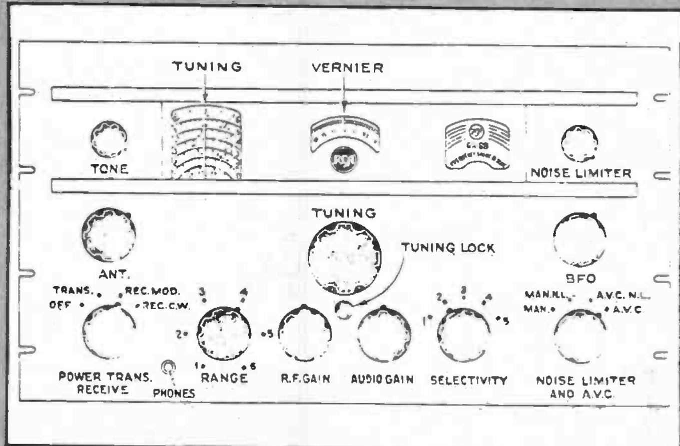
In general, sensitivity is adequate but the signal-to-noise ratio on the HF bands, ie, above 15MHz could be better. This is generally improved by the use of a low-noise pre-amplifier ahead of the receiver. A tuned pre-amplifier or even an antenna tuning unit will improve image rejection above 15MHz.

Although the electrical and mechanical design is inherently stable there is often a problem with frequency stability and re-setability above 15MHz. This derives from several causes – mainly a direct result of the age of the specimens available. Firstly some 6J5s tend to be microphonic and careful selection is necessary. Thumping the front panel is a good test and tapping the valve envelope. On a secondhand receiver of this vintage there are often bandswitch problems. Generally this is not due to wear or damage but simply dirt and grease which has accumulated over the years. It can be solved by the careful application of switch cleaner. This involves the removal of the coil-pack covers and a large number of nuts. Do make sure that you replace every one and when you gaze on the beautifully constructed coil do resist the temptation to touch it any more than is necessary!

Finally there is instability caused by ageing of components which can cause both frequency instability and gain instability. The worst offenders are capacitors used for decoupling. The capacitors used in the AR88 for this purpose are either moulded mica for small values or oil-filled paper for the larger values and both have a very good reliability record so approach this problem with care! If it proves necessary to replace any moulded mica capacitors in the RF, LO or IF sections then use only polystyrene of a suitable value and working voltage. The author discovered in his receiver that a previous owner had replaced all RF and IF coupling capacitors with Hi-K Disc ceramics; this included decoupling capacitors in the Local Oscillator and the BFO. Their replacement with polystyrene capacitors made a dramatic improvement to Local Oscillator drift.

So far no open-circuit resistors have been found but if gain or signal-to-noise ratio is thought to be below par then it pays to check screen-grid decoupling resistors/capacitors – assuming that the valve concerned has first been tested. Design of the RF and IF amplifiers is very conservative and results in stable performance. If instability is experienced when aligning the receiver then the relevant circuit components should be carefully checked.





Above: With the top casing removed, this is what you see. Right: Diagrammatic version of the front panel, showing all controls, what they do. The panel should be unscratched and clean if the price is around the upper limit. Make sure the tuning drive gears are not worn or distorted. Below: IF bandwidths for all switch positions.

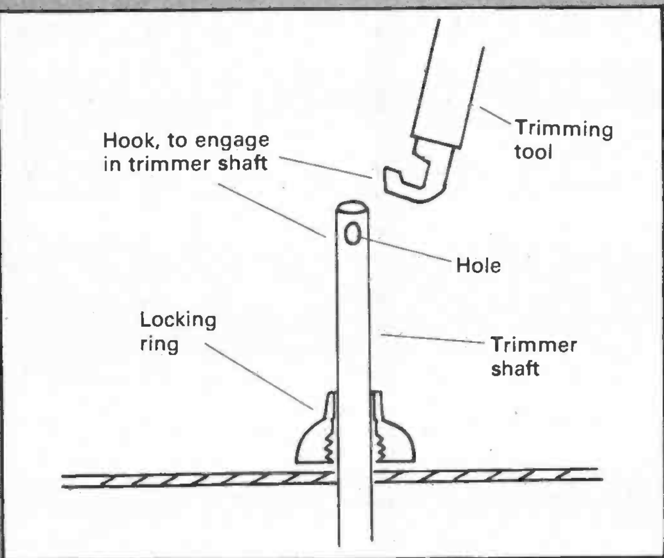
Finally, in purchasing an AR88D, examine carefully the physical state of the equipment. In the upper end of the price range the appearance should be clean and unscratched with no sign of modification. Check that the tuning drive gears are not worn or the assembly distorted. There should be evidence of grease on the gears and the drive should be smooth and positive with no 'slop' or backlash. Ideally it should come complete with a handbook, two trimming tools and an Allen key clipped inside the cabinet. In many cases it may have the original packing crate and a spare set of valves.

SELECTIVITY SWITCH POSITION	*BANDWIDTH KHz*	
	3dB	*60dB*
1	*14*	*22*
2	*7.0*	*16*
3	*3.0*	*11*
4	*1.5*	*10.4*
5	*0.4*	*8.4*

We shall now look at the alignment of the AR88. In my experience recalibration is necessary from time to time but the IF alignment deteriorates very slowly. Do not undertake realignment unless you have the time and patience to do a complete and careful job; tweaking up is not recommended!

Ideally an oscilloscope and a sweep generator is required to achieve the very best results. However, with a little care it is possible to

SIGNAL TYPE	MODE SWITCH	AVC SWITCH	RF GAIN	AF GAIN
AM	REC. MOD	AVC OR AVC-NL	CLOCKWISE	AS REQUIRED
CW	REC. CW	MANUAL OR MANUAL-NL	AS REQUIRED	CLOCKWISE
SSB	– AS FOR CW SELECTIVITY POSITION 3 –			
FM	REC. MOD	MANUAL OR MANUAL-NL	AS REQUIRED	C/W
	USE SELECTIVITY POSITION 3 OR 4			



Above: This is a general guide to the control settings on AM, CW, SSB, and FM signals. There is, naturally, more information in the original manual – if you can obtain one. They are almost as valuable and rare as the equipment itself! Left: Details of the trimmer and the tool with which it can be adjusted. A well-kept AR88 should come supplied with two trimmer tools and an Allen key inside the cabinet.

achieve very good results using a high impedance voltmeter and a stable signal source – I use my BC221 frequency meter. A signal generator is preferable however for the RF alignment, provided that its calibration is reasonably accurate and it is stable. Beg or borrow one if necessary! Beware though some of the cheaper signal generators on the market have inaccurate calibration and are unstable even at 455kHz! It is essential that, with the signal source used for the IF amplifier alignment, one can estimate +/– 7kHz from the central Intermediate Frequency.

Alignment must commence with the IF amplifier. Although the handbook gives the intermediate frequency as 455kHz this is the nominal value. The value which we shall use is the actual value of the receiver's crystal filter which will probably differ from the nominal value by a small amount.

Connect a high impendance voltmeter of the analogue type (eg: AVO8 or similar 20000 ohms/volt) on its 5 volt range to terminal 5 on the rear terminal strip which carries the loudspeaker connections; the positive lead of the meter being connected to chassis. Connect the signal generator via a 0.01μF capacitor to the frequency changer signal grid (6SA7 pin). Select Selectivity switch position 5, mode switch 'REC MOD' and AVC switch to AVC (fully clockwise). Sweep the signal generator either side of 455kHz looking for maximum reading on the voltmeter. The signal generator (unmodulated) level should be reduced if necessary to keep the volt meter reading around quarter-scale and to avoid overloading the receiver. The frequency at which the maximum voltmeter reading is obtained should be noted; it should be within a kHz of the nominal IF.

In the extreme case, where no output at all can be detected, it will be necessary to roughly align all the IF transformers to the nominal 455kHz by injecting a signal at each IF grid starting with the third and working back towards the mixer grid with the selectivity switch in position 2. At each stage the IF transformers are adjusted for maximum reading on the voltmeter. However this is an extremely unlikely circumstance and one should look for faulty valves or components before making any adjustments.

To proceed with the alignment assuming that all is well and we have the signal generator set to the frequency of the crystal filter as above. Set the selectivity switch to position 2 and the crystal phasing (C75) to its mid-way position. Now adjust all IF transformers for maximum reading on the voltmeter working from the detector back towards the frequency changer; reducing the signal generator level where necessary to avoid overload. Now select selectivity switch position 3; set to the signal generator frequency 7kHz above the crystal frequency and adjust the crystal phasing (C75) for minimum meter reading. All that now remains to be done is the adjustment of the crystal load circuit. The purpose of this adjustment is adjust the symmetry of the IF response about the centre frequency nd it is very difficult to carry out with the equipment we are using here. Ideally we need a sweep generator and an oscilloscope. The following procedure can be used only with patience, otherwise leave the adjustments as they are. First tune the signal generator to approx 1.2MHz; set the receiver band-switch to band 1 and tune for maximum deflection on the voltmeter, reducing the generator output as necessary to avoid overload. Select position 3 on the selectivity switch and note the two vernier logging scale readings for which the voltmeter reading falls to half the maximum value. Adjust L34 to obtain as near equal distances on the logging scale for these two readings either side of the setting which gives maximum reading. This procedure is repeated for selectivity switch positions 4 and 5 adjusting L81 and C80 respectively. Note that the dial readings and the adjustments will become progressively smaller and more critical.

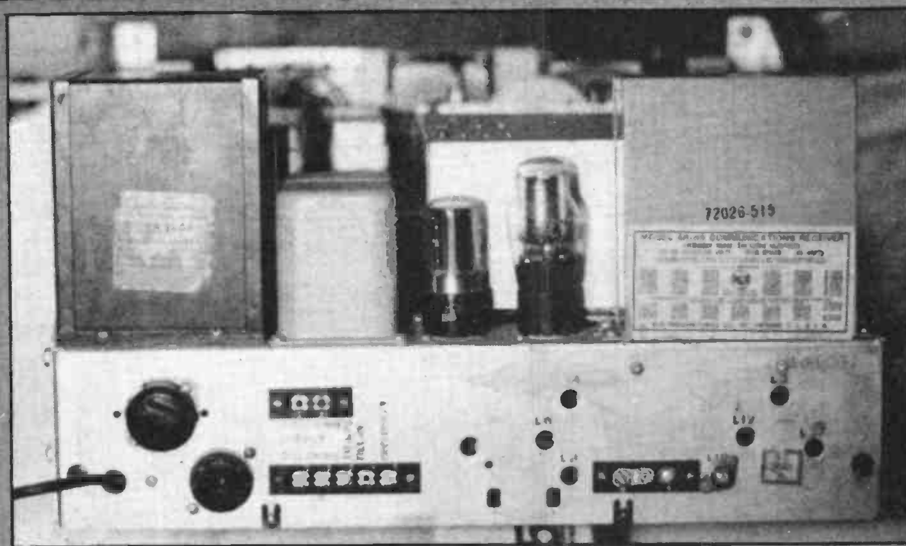
All that now remains is to set up the BFO. Using the above set-up, tune the receiver for maximum reading on the voltmeter. Set the BFO pitch control so that the pointer is at the 12 o'clock position (check that the variable capacitor coupled to this knob is at half-mesh – if not then slacken the knob and adjust it). Set the mode switch to 'REC CW' and adjust L22 until the whistle that is heard falls to zero-beat. The BFO should now give approximately 3kHz variation in pitch either side of zero-beat. Return the mode switch to 'REC MOD'.

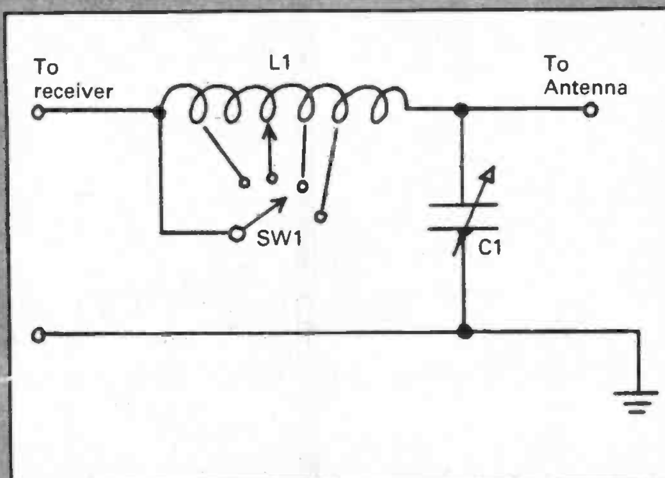
Alignment and calibration of the RF section is quite straightforward but requires even more patience! It is possible to achieve very close agreement with the dial calibration over the whole of each range even though only a two-point tracking system is used (this is due to the design of the ganged tuning capacitor). The accuracy to which the dial can be set is only about +/– 5kHz but this is probably superior to most signal generators with an analogue readout. If a frequency meter of the BC221 class is available – or even a 100/1000kHz crystal calibrator then this can be used to put the finishing touches to the calibration but the initial calibration and alignment should be done with a signal generator. The reason for this is the poor image rejection at frequencies above 10MHz – particularly when the receiver is not correctly aligned – which could lead to the receiver being aligned to the wrong signal.

It will be found necessary to repeat each sequence several times before optimum calibration or performance is obtained. The procedure is as follows:-

In all cases use the signal generator with modulated output since this makes it easier to identify. The output level should be set to produce a one or two-volt reading on the voltmeter and should be reduced where necessary to avoid overloading. Set the generator frequency to the high frequency for the band concerned and tune the receiver to find it. Adjust the appropriate trimmer to bring the signal near to the correct dial reading. Now set the generator to the low frequency and adjust the appropriate trimmer to correct the calibration. Repeat this procedure until the two signals appear at their correct dial readings. The trimmers concerned should be adjusted using the tools provided with the receiver. At the low frequency end this involves the core of an inductor and an insulated screwdriver blade is suitable. At the high frequency end, trimmer capacitors are involved which are of an unusual tubular construction. The AR88 tool provided for this has a box-spanner at one end to release the friction lock and at the other end there is a hook. After releasing the locking nut so that the central part of the capacitor will just move this central part is adjusted by sliding it in or out by engaging the hook on the tool in the shaft end – see fig. 8. Remember to lock the trimmer when adjustment is complete.

The RF amplifier is adjusted in a similar way. The antenna trimmer on the front panel should be initially set to the 12 o'clock position. With each adjustment tune for maximum voltmeter reading repeating the adjustments until no further improvement is obtained. As each stage comes into alignment the generator output should be reduced to avoid overload; the final output level should be around a microvolt or less.





Above: The AR88 with its rear panel removed. Right: A simple antenna tuning unit for the frequency range 1.5MHz to 30MHz.

C1 500pf variable capacitor.
L1 35 turns 18 SWG enamelled copper wire on 2 inch former (eg a length of plastic drain pipe) tapped at every 3 turns.
SW1 12 way rotary switch eg R.S. heavy duty.

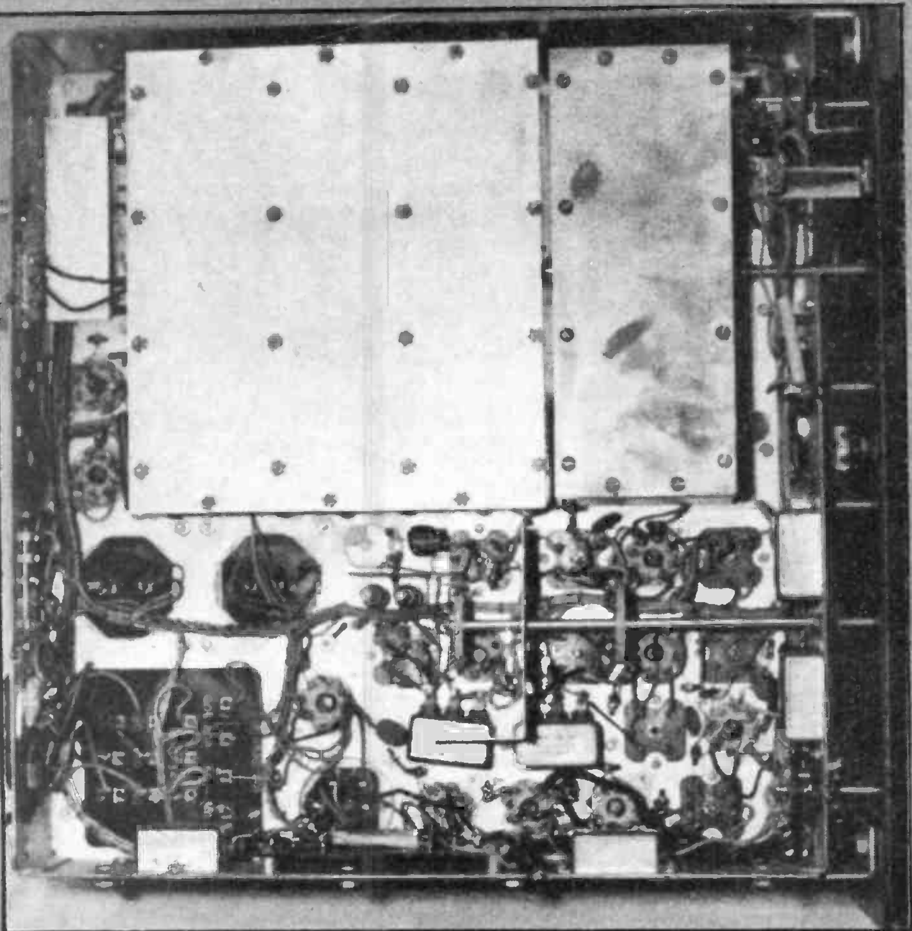
A final check should be made by setting the signal generator to a frequency in the middle of each band and checking that it appears in the right place on the dial. Adjust the antenna trimmer for maximum output and check the level of the image signal by tuning the generator to a frequency which is 910kHz (ie, 2 × IF) above the frequency to which the receiver is tuned. If the generator has a calibrated attenuator you can estimate the image rejection ratio by adjusting the generator output until you obtain the same reading on the voltmeter as you had at the correct response frequency. The ratio of the two readings is the image rejection ratio.

The receiver is now aligned and ready for general use. One final touch whilst we have the test gear to hand is to note the logging scale readings for each of the amateur bands – including the three new ones – using a crystal calibrator if you have one.

Finally let us look at the operation of this receiver. It is not intended to give a blow-by-blow description but rather to concentrate on how to use it to advantage particularly with the two modes for which it was not specifically designed. It was originally designed for reception of telegraphy (CW) and amplitude modulated telephony. With a little understanding it can be used effectively for SSB and narrow-band FM also.

The mode switch in the bottom left-hand corner of the front panel has four positions; 'OFF' removes the mains supply completely. In 'TRANS' the HT supply is removed putting the receiver in a standby mode. In this position terminals 3 and 4 on the loudspeaker terminal strip are shorted together and can be used to energise an external relay for transmitter operation. In 'REC MOD' the receiver will receive modulated transmission whilst in 'REC CW' the BFO is energised for CW reception.

The switch in the corresponding right-hand position controls the AVC and Noise-Limiter and is self-explanatory. The noise limiter threshold is set by the control above the BFO pitch control. There is a combination of these controls which should be used as a general guide for reception of the various modes but which may well be modified by conditions prevalent at the time. Let us now look at some of these in



sideband of an amplitude modulated signal – and again there are an abundance of broadcast intruders in the 7MHz amateur band on whom to practice. If we tune carefully across an AM signal with the BFO and AVC off, two points, one on either side, should be found where the signal becomes unintelligible. At these points we are receiving a single sideband only and the carrier is positioned down one side of the IF response curve. Now switch on the BFO; a beat note will be heard. As the beat-note is adjusted for zero-beat the signal should become increasingly more intelligible. Note the position of the BFO pitch control and repeat with the other sideband. The two positions of the pitch control will be roughly correct for receiving amateur SSB and can be 'refined' by first tuning AM SSB signal for maximum signal, then adjusting the pitch control to make the signal intelligible.

The reception of narrow-band FM, which is becoming quite popular at the HF end of the 28MHz amateur band, is also quite simple – and there are always plenty of CB stations on 27MHz to practice on! The technique, known as slope detection, uses the IF response curve to convert the frequency modulated signal into an amplitude modulated signal and in doing so there is a loss in signal strength, but this is rarely appreciable. The FM signal is tuned using selectivity position 3 or 4 so that the centre of the signal lies down one side of the IF response curve. Frequency modulation produces variations about this central frequency which in turn move the signal up and down the 'slope' of the IF response resulting in an AM signal to the detector. The above techniques are shown graphically in fig. 10.

Well, that was a much-abbreviated run through on how to drive the AR88; the key-word here is practice. The receiver will acquit itself well, even with a piece of wire on the floor for an aerial – but of course it deserves better. The aerial input circuit is designed to match into an impedance of 200 ohms but I have found it will work very well with a 70 ohm coax feeder. A random wire antenna coupled via a tuning unit (for example fig. 11) will give very good results and the tuning unit will help also to reduce image interference on the 21 and 28MHz bands.

Being a general coverage receiver it comes ready equipped for the three new amateur bands of course. Buy an AR88 and enjoy a real receiver.

more detail:-

First the reception of CW, ie, telegraphy. Here we have in effect a single frequency and all we have to do if there is no interference is to tune for maximum signal and set the BFO pitch control to give the required beat-note in the headphones or loudspeaker. In general the receiver is used with the AVC off so that the BFO injection does not reduce the receiver sensitivity. The AF gain is set fairly high and the receiver gain is controlled by the RF gain control. Of course this ideal situation rarely exists; there is usually an abundance of adjacent-channel interference and this is where we learn to 'drive' the receiver. Clearly we have a case for using the crystal filter and the technique is best practiced on a strong signal such as one of the broad-cast stations in the 7MHz amateur band. Switch the selectivity switch to position 3 and the BFO pitch to one side of the zero position – say to 1 o'clock.

As you tune through the signal note how the strength of the beat-note is much stronger on one side of zero-beat than on the other. Shift the BFO pitch control to say 11 o'clock and note how the position is reversed. Put the BFO in the zero position and the beat-note strength is the same on both sides of the zero-beat position. Repeat the exercise with the selectivity switch in positions 4 and 5 and note how very much more pronounced the effect is.

This is the view you get if you removed the bottom housing from the AR88. The inner casing on the right houses the oscillator coil pack, by the way.

We make use of this effect in receiving CW in two ways . Firstly, if possible we tune the wanted signal so that it sits at the top of the IF response curve – with the BFO on one side or the other of zero – and unwanted signals down the side of the response and therefore attenuated. If the unwanted signals are very close to the wanted signal then we can do one or two things; both using maximum selectivity. We can adjust the BFO to the other side of zero-beat so as to make the interfering signal differ more greatly in beatnote, or adjust the BFO pitch to reduce it to zero-beat. Alternative we can adjust the receiver tuning to place the offending signal further down the side of the IF response at some sacrifice in the strength of the wanted signal. All this may sound difficult but it becomes quite easy with practice.

Now let us look at SSB. In selectivity position 4 it is possible to select each