THE AR7 AND S.S.B.

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ALTHOUGH designed some 25 years ago, the AR7 receiver still ranks as an exceptionally fine general-purpose communications receiver and is much sought after by discerning Amateurs for a number of reasons.

These include the fact that it can be put into use in Amateur service without any modifications, and in this regard, is somewhat unusual in equipment obtained from Services sources. Because of its straightforward design it is capable of being modified for special services, without very much trouble and in a manner which does not destroy its re-sale value. Also its performance, as a general-purpose receiver, is outstanding when its owner learns how to use all its capabilities.

However, in common with all general-purpose receivers, it does need modification for special services such as the Amateur service and some time ago a very fine series of articles appeared in "Amateur Radio" covering some worthwhile modifications.[1]

With the advent of s.s.b. into Amateur practice the AR7 revealed some shortcomings, in what was for it, a new type of use. It must be remembered that when the AR7 was designed, a long way back in the late thirties, s.s.b. was little used except in overseas radio telephone circuits, probably none was used in the Defence Services, and as a result the specification for the AR7 did not include provision for s.s.b. It is also well worth while remembering that many similar receivers of overseas origin did not include provision for s.s.b. until within the last couple of years, when the popularity of Amateur s.s.b. created the necessary demand.

All this is not to say that an unmodified AR7 cannot be used on s.s.b. It can, but the operation of resolving both s.s.b. and d.s.b. is a rather difficult operation. Yet with a few simple modifications, which need not destroy the looks or re-sale value of the set, the AR7 can be made into a receiver that is a pleasure to handle on s.s.b.

The purpose of this paper is to outline such a series of modifications made to the AR7 at this station.

Four modifications were made, these being:—

- Improvement to frequency stability of both r.f. and beat frequency oscillators.
- Fitting a product detector for better c.w. and s.s.b. work.
- Improving the tuning rate, mainly by bandspreading.
- Fitting an improved tone control.

PRODUCT DETECTOR

For mechanical reasons it is desirable to fit the product detector first. The product detector theory has already been covered in articles[2] in "A.R." and will not be repeated here. Due to its action it gives an apparent reduction in some forms of QRM and is very helpful with static. It is not generally realised that the product detector requires a very small input and as a result its output is also low. This misconception has given rise to the thought by many Amateurs that it is not worth using. This is far from the case as the disadvantage of low output is more than made up by its worthwhile characteristics. One thing the product detector does do is to show up ordinary a.m. transmissions which have either f.m. or frequency drift in them; it also displays perfectly the ability or otherwise of an operator's netting abilities.

Fitting the Product Detector.—This is provided with an Oak wafer switch, so that either diode or linear detection can be used. The switch is mounted in the top right hand corner of the front panel (looking at the front of the AR7). With a square along the top of the panel draw a light pencil line in the same line as the centre of the crystal switch. Then with the square laid on the right hand end of the panel, cross this pencil line with another which is in line with the tone control and the noise limiter shafts.

At the point of the cross, drill a hole through the panel and mount the wafer switch, keeping it as close to the back of the panel as possible. Note that the switch is a four-position one. This arrangement reduces leakage across the switch.

A hole to take a large rubber grommet is now drilled in the chassis to take the wires from the switch, and to those of the voltage regulator valve which will be fitted in the second stage of the modifications. This hole is drilled alongside the end of the gang condenser shield and just back of the crystal filter shielding. Make certain that the hole does not foul anything under the chassis.

Turn the chassis over and along the end wall of the chassis underneath the output transformer, drill a horizontal line of small holes to provide ventilation. On this end wall mount a nine-pin socket, on a couple of pieces of copper tubing. Use countersunk screws so that the outside of the chassis will be smooth. To find the location for this socket, first mount a 7,500 ohm, 20 watt, resistor on the back wall of the chassis just under the second aerial terminal. This resistor will project out into the chassis, being mounted with a long bolt. The product detector valve must clear this resistor as much as possible without being placed too near the b.f.o. shield.

Little comment is needed on the circuitary of the product detector. The two voltage splitting condensers are mounted as close to the plate of the second i.f. valve as possible, and a short section of co-ax used to connect the junction of these condensers to the product detector valve socket. The two grid resistors of the 12AU7 valve and the cathode resistor should be wired directly to the valve socket and to the nearest common earth point.

After installation of the product detector, it will be necessary to re-align the last i.f. transformer due to the slight extra loading of the product detector. It will also be necessary to re-adjust the slug of the b.f.o. coil slightly. Do not worry over the use of the piece of co-ax in the circuit. Its position places its capacity across the lower of the voltage splitting condensers and is part of the design. It will be noted that the circuit shows that the volume control of the 6G8G has its low potential end connected to earth. In most AR7's, this is returned to the a.v.c. net-

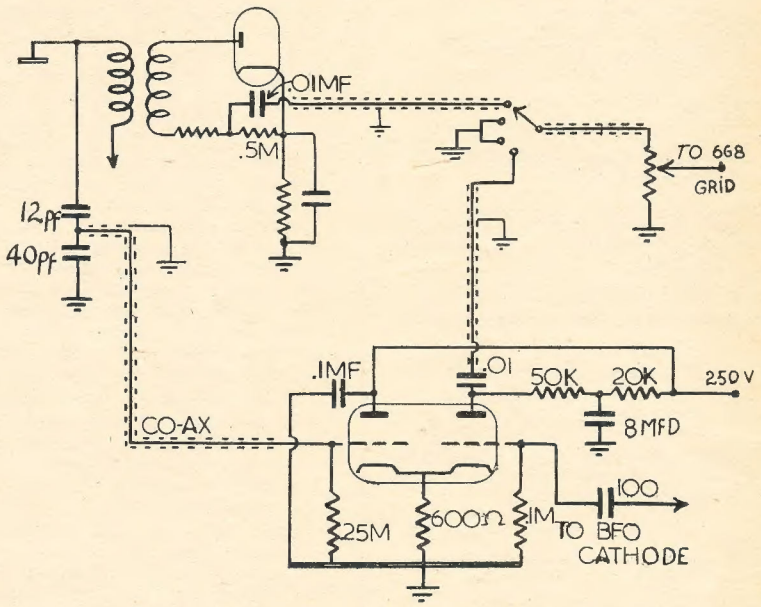

Fig. 1.—Product Detector for AR7.
Note alterations in the diode circuit. Components not marked are original.

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work to give audio a.v.c., but in the receiver here this was not done by the manufacturer, although the components were included. Possibly there was a wiring omission in the factory, or some models were altered for a definite requirement. This is mentioned because the instruction book does not show this variation.

In using the product detector it will be found that a.m. stations can be read without the b.f.o. being switched on, if a high signal level is fed into the detection system. This is mainly due to the fact that the diode is also operating and is coupled into the 6G8G cathode. By turning back the r.f. gain control this leakage disappears and a.m. stations then require use of the b.f.o. to obtain detection.

There is a slight tendency for the set to motorboat when using the product detector, when the audio volume control is turned up very high, but this is of no consequence here as the speaker output as this point is too high anyway and would only worry the neighbours. So much for the product detector.

FREQUENCY STABILITY

Whilst the stability of the AR7 is of a high order, it can be improved still further and is a must for s.s.b. Two things were done here, the first being to fit a 5 pF. negative temperature condenser from the stator of the h.f. oscillator to the frame of the condenser. This was fitted at the top of the condenser when looking down into the set and has helped quite a lot. All coils then want re-aligning slightly to bring them back to calibration.

The second approach to the stability problem was to use voltage regulation on both oscillators. A voltage regulator valve, VR150, was mounted horizontally in the set in the space between the wafer switch for the product detector and the shield of the crystal, keeping it as far away as possible from the latter. A small octal socket was mounted on the end wall of the chassis, using short sections of $\frac{1}{4}$ inch copper tube as spacers. The cathode of this valve is taken to the common earth system under the chassis, whilst the anode is connected to one end of the 7,500 ohm 20 watt resistor mentioned before. The h.t. connections to the h.f. and b.f. oscillators were traced and were connected at the resistor where it goes to the anode of the regulator valve. The b.f.o. dropping resistor was short circuited. The dropping resistors to the h.f. oscillator were not removed, but a 6J8G valve was substituted for the original 6K8G.

These simple modifications have made a big difference to the frequency stability and it is now felt that most of the drift which occurs when tuned to WWVH is due to the b.f.o. The drift is far less than that observed on many Amateurs, including the s.s.b. stations.

TUNING RATE

S.s.b. demands that the receiver have a very slow tuning rate as it is necessary to tune the receiver and set the b.f.o. within a few cycles of the original carrier. As mentioned before, the AR7 can do this but it's a rather tedious affair and if several stations are in an s.s.b. network and are not exactly netted, then matters become very complex for the listener. The first thing to be done is to improve the ability to set the b.f.o. and this is done by substituting a large diameter knob for the small one. A bakelite knob of the same diameter as that on the main dial will just fit, without fouling the b.f.o. switch. A similar knob should be placed on the crystal filter phasing control, not only to balance the looks of the set, but to give an added vernier effect when tuning the crystal filter. The next thing to be done is to bandspread the coil boxes. Data for bandspreading for the 14, 21 and 28 Mc. bands has been given in the excellent series of articles mentioned before.

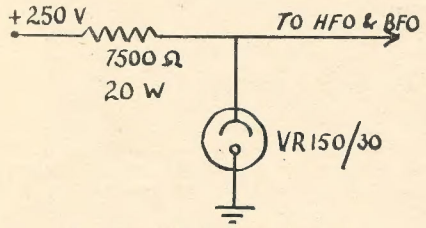

Fig. 2.—AR7 Voltage Regulator.
The jumper in the VR150 is not used.

However the amount of bandspread on the 7 Mc. band leaves a lot to be desired. Therefore a coil box was modified and bandspread is now such that the box covers only 7.0 to 7.19 Mc. Whilst this amount of bandspread makes the AR7 appear to have the selectivity of a crystal set, it does make the tuning in of s.s.b. stations a very simple matter.

Details of the modifications are as follows:

1st r.f. coil.—14 turns of 18 gauge enamelled wire wound on a $\frac{3}{4}$" slug-tuned former. Length of winding, 1". Primary, 3 turns of 30 en. wire interwound with bottom three turns of the secondary.

2nd r.f. coil.—As above, but primary has six turns.

Mixer coil.—As above, but primary has nine turns.

Oscillator coil.—9 turns of 18 gauge en. wire wound on a 1" diameter former, slug-tuned. Length of winding, $\frac{3}{4}$". The plate winding is four turns of 30 en. wire interwound with bottom turns of grid winding.

Across the small trimmer condenser in the coil box are mounted two silver mica condensers, one of 100 pF. and the other of 25 pF. (if a band C box is used it will have two trimmers. Connect these in parallel and delete the 25 pF. condenser). On each coil assembly locate the short lead that connects the grid end of the winding to the stator of the gang condenser. Replace this lead with a silver mica condenser of 20 pF.

The boxes are re-aligned by using the slug to set the box to 7.0 Mc. with the dial at 500, and the trimmer is used to set the box to approx. 7.2 Mc. with the dial at 0.

As in use here, 7.15 Mc. occurs at 130 on the dial when 7.0 Mc. is found at 500. There is a certain amount of interaction between the trimmer and the slug in each box when aligning the coils. The method used here was to connect a signal generator to the grid of the mixer valve, through a small condenser with a half meg. resistor as grid leak to earth.

With the gang condenser at minimum capacity the oscillator trimmer was adjusted to get a signal on the high side. The generator was then moved lower in frequency and the slug adjusted. Several repetitions were required to get the tracking correct. When this was done, the signal generator was moved to the grid of the 2nd r.f. stage and the mixer grid coil was adjusted. The same procedure was carried out with the other coils.

If it is thought that this is too much bandspread, then it is possible to remove the 25 pF. condenser from the coil assembly and increase the value of the series condenser from 20 pF. to 47 or 50 pF. This will then place 0 on the dial at about 7.450 Mc. when 7.0 Mc. falls at 500 on the dial.

This method of bandspreading could be used with the existing coils in an existing D box, but a spare one was not available here, so a spare C box was used.

TONE CONTROL

The tone control as fitted to the AR7 is the type used in most b.c. sets and simply cuts off the higher audio frequencies. The tone control shown in the circuit was installed.[3] When the arm of the pot. is at the earthed end, there is a certain amount of treble cut, but this is not carried to extremes. With the arm of the pot. at the other end, there is treble accentuation and an amount of bass cut. If a linear pot. is used, the system will give a flat output with the arm in the centre position.

This type of tone control assists greatly when listening to stations which are "boomy" due to distance or other causes. It also helps the intelligibility under bad conditions and has been found a worthwhile feature.

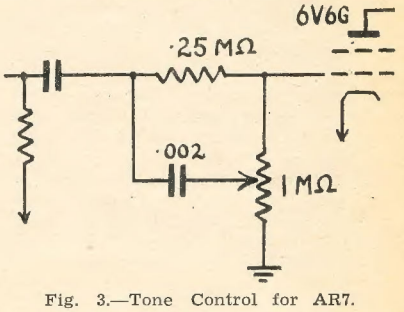

Fig. 3.—Tone Control for AR7.
Components whose values are not shown are normal receiver components. This tone control gives treble cut, through flat response to bass cut with slight treble increase.

TUNING S.S.B.

The method of tuning s.s.b. is to tune the receiver with the r.f. gain control at maximum, for greatest output from the receiver, for any given audio volume control setting. This peaks the sideband in the bandpass of the receiver's i.f. system. The r.f. gain is then turned down, the b.f.o. switched on, and adjusted until the speech becomes natural. If necessary, the r.f. gain is adjusted as well as the b.f.o., but this is not as important with the product detector as it is with the diode detector. Audio volume is controlled

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with the audio volume control. In many instances best results are obtained with the r.f. control right off.

No bandspreading has been applied to the 3.5 Mc. band as, so far, it has not been found necessary.

Due to the large bandspread on 7.0 Mc., there is an apparent lack of selectivity. This is typical with all systems using such a large amount of bandspread and a 455 Kc. i.f. system. The crystal filter of the AR7 will help a lot and the receiver's i.f. channel should be lined up with the crystal, which is nominally on 455 Kc. Changing crystals can cause a lot of poor reception when the filter is in use and each set should be adjusted with its own crystal in circuit. Replacing the second and third i.f. transformers with the latest Aegis high selectivity transformers will also help. The crystal filter input transformer should not be replaced unless a satisfactory replacement is available.

A Command Q5'er, connected to the grid circuit of the 2nd i.f. stage by twisting a couple of turns of wire around the grid lead will work wonders as far as selectivity is concerned. However, it will probably be found that under the condition of extreme selectivity that is then obtained the tracking of the AR7 is not perfect. A similar check on a lot of other receivers will reveal the same thing.

Finally, remember that a receiver is only as good as its operator and these modifications will make the operator's life a lot easier and allow him to get more enjoyment from his receiver, the old faithful AR7.

REFERENCES

1. "Modifying the AR7," "Amateur Radio," May, June, July, August, September, 1957; December, 1958; January, 1959.
2. "Amateur Radio," April, 1959.
3. "Radiotron Designer's Handbook," pages 662 and 663.