ABOUT THE HRO RECEIVER

CHECKING PERFORMANCE —ALIGNMENT, ADJUSTMENT, AND GENERAL SERVICING

Part I

E. P. ESSERY (G3KFE)

With many hundreds of HRO's of various marks still in amateur-station use, this article will be found very helpful by those who may feel that theirs might be needing some attention. In the second part of his article, our contributor will discuss possible modifications to modernise the HRO to the standard of present-day requirements.—Editor.

THE National HRO is a receiver about which little has been written in recent years, although a large number have appeared on the surplus market. In view of the absence of recently-published information, and the fact that, at its present low price, the HRO represents probably the best buy for the beginning (or experienced) licensed amateur or SWL (apart, of course, from the latest in post-war amateur-bands-only crystal-controlled receivers) it is proposed to cover, in fair detail, the receiver in its basic form, and also to discuss a series of modifications to make it more suitable for present-day use. It goes without saying that a copy of the HRO Manual would be extremely useful in following the discussion.

The Basic Circuit

This is shown as a block diagram in Figure 1. This arrangement is of the HRO-MX; it also goes for the HRO-5 with the exception that the valve types are different. The HRO Junior is basically the same, but lacks the crystal filter components and the S-meter circuit, and was not normally sold with bandspread coils.

Additional Requirements

In order to operate the HRO a loudspeaker with output transformer is required, the transformer being of the 6V6-to-speaker variety available in all good junkboxes. It should be noted that in the absence of the primary of this transformer, wired across the "Speaker" sockets at the rear of the receiver, application of HT will result in the output stage having screen but no anode volts. This is bad for the valve! If it is intended to run on phones only, then the speaker sockets should be jumpered together at all times.

An external power supply is required. For 6·3 volt models, it should be of 230 volts DC at about 75 mA, with a centre-tapped heater winding at 6·3 volts 3·1 amps. If a receiver is met with using the old 2·5 volt valves on UX bases it is recommended that the change be made to the standard types (which it is understood are interchangeable) provided that *all* the valves in the receiver are changed at the same time to 6·3 volt heaters. If an HRO-*B* is encountered, it is a battery type; it takes the same heater current but needs 180 volts HT at 55 mA on the HT line. All bias requirements are provided for within the receiver. Any old power pack giving this sort of performance will do for the first tests, and will serve quite well on Top Band (or any other band where only the reception of AM phone is required) but, in getting the receiver right up to scratch, we will see that a fully stabilised supply is to be preferred.

Some sort of aerial, and some sort of earth, may be hung on the terminals at the side of the receiver on the left, and the GND terminal joined to earth by a short jumper.

Getting it Going

Having connected the power supplies and an aerial, throw the "B-plus" (HT) switch on and let the receiver warm up, then check operation on one or other of its ranges—the medium-wave to Top Band coil being probably the most convenient. A good idea of the liveliness, or otherwise, of the receiver will soon be evident. If the receiver seems to be running reasonably well then remove the case and base-plate (the method of doing this depending on whether the receiver is of the rack or table model) and carry out the following checks: (1) Remove and test all valves, returning all good ones to their original sockets and replacing any that are doubtful by new ones. (2) Disconnect and measure the resistance of all the 0·1 μF capacitors, using either a megger or a high voltage tester of the type

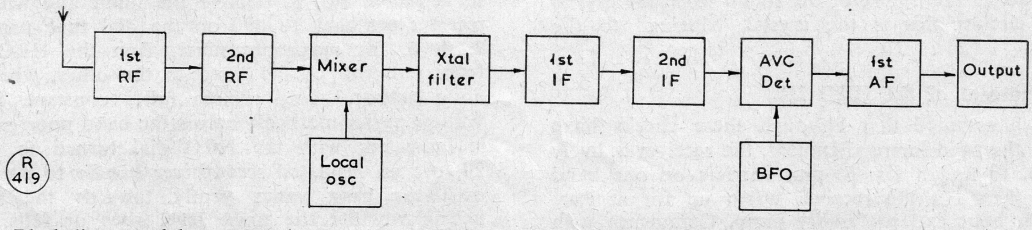


Fig. 1. Block diagram of the war-surplus type National HRO receiver. There are several variations, but the general arrangement is shown here. The main features of the HRO are its superlative tuner unit and the fact that it uses plug-in coil packs, for either BS (bandspread) or GC (general coverage). It requires a separate PSU and an external speaker.

shown in Fig. 2, it having been proven from painful experience that the usual test with the multi-range meter does not, for some reason, weed out all the bad ones. (3) Check the valve voltages to be approximately as in Table II, which were taken on the writer's HRO-5 before modification using the meter at the specified control settings of the receiver and on the specified meter ranges. The figures are quoted for a Caby Model B-20 and also for the Taylor 120A. The figures actually found should be noted down as they are taken and kept to provide a quantitative guide for any future fault-finding and as a check on running deterioration which affects all receivers in time and is so hard to assess without some reference.

An operational check should now be made. Set the controls as follows: RF Gain to maximum; Phasing to one end of its travel; CW Osc. to Off; AVC to Off; B-plus to On; Selectivity to the position of maximum noise output, and aerial and earth disconnected. If the alignment of the particular coil-set in use is all right then on spinning the dial from one end of the band to the other, the noise will stay at a constant level, or very nearly so. The coil-set may now be said to be in alignment or out of line, with the minor reservation that a faulty coil-set may also show constant noise level albeit at a lower level. Such a coil-set can be identified by noting the behaviour of each one of the coil sets available at the same session so that one which is not "perking" is contrasted against the others which are all the same.

In a similar manner the IF alignment can be checked: Adjust the receiver as for the previous check but with the following alterations: Phasing set to about 5, i.e., switching in the crystal; Selectivity at maximum with the knob set to zero; CW Osc. turned away from Off. Under these conditions noise will be heard, the pitch varying when the CW Osc. control is turned. The noise will come to its lowest pitch at about 9 if the receiver is set up as its maker meant it to be, and if it has been in amateur hands it will more likely appear around 5; either way, note the exact setting at which the condition of lowest pitch of noise occurs. When this has been done repeat the test with the Phasing switched round to zero and Selectivity peaked for maximum noise output. The point of lowest pitch should appear at the same BFO setting if the IF is aligned correctly, and any difference in the two results indicates a need to realign. Note during this test a slight difference in the *timbre* of the sound when the crystal is in circuit; this is the crystal "ringing" to the noise.

Re-alignment of the HRO IF

It is assumed that although these checks have shown the need for re-alignment, the receiver is lively enough to find a few S9-plus carriers on one band or another. Let the receiver warm up for at least half an hour and preferably more. Commence with IF alignment as follows: Set the receiver to the condition of maximum selectivity as indicated in the first IF check in the last paragraph. Tune to a CW carrier and note as you do so the pronounced "ringing" as you go through the signal; settle the tuning at the point where the ringing is most pronounced, and, without altering the controls in any other way adjust the CW Osc. for the favoured BFO pitch. Trim the IF trimmers Nos. 10, 11, 12, 13, 14 (see manual) for maximum response. It will be necessary to check that the receiver is tuned dead on in the "ringing" region, and as the IF shows signs of increased life, the work should be done on weaker and weaker signals, so that it is not necessary to reduce the RF Gain. The favoured signal for this is an unmodulated carrier at about S4 or less. Repeat and again repeat the work, and end up by repeating the IF check previously described. If the point of lowest pitch of noise does not now coincide whether the crystal is in or out—hard luck, and back to Square One. You *must* get the receiver alignment to pass this test, and repeating until you do is good practice anyway!

HRO Front-End Re-alignment

For the coils from 900 kc to 30 mc, we can notice that the MW coil has Top Band at one end and a stack of BBC stations at the other, while on the other coils an amateur band appears at each end of the range, so that in each case it can be established with some precision whether the coil-set in hand meets the calibration of the general coverage graph on the front to an accuracy of better than 3 per cent over the range. If it does, well and good, although it ought to be a lot better than this over the parts of the calibration occupied by the amateur band at each end. If it is not then the oscillator is out and needs re-aligning as follows: Set the signal to a frequency which should be at 490 on the HRO dial if tracking were OK, and check this signal frequency against the station wavemeter. Tune it in on the HRO, and then adjust trimmer No. 8 (*see* hand book) till the signal is where the HRO calibration chart says it ought to be. Then tune the receiver 912 kc *lower* in frequency, run up the RF again to max and see if you can find the signal as a weaker image. If you cannot locate the image the chances are that you have tuned the oscillator on the wrong side of the signal. This last check *must* be made or the receiver cannot track properly; the image rejection varies from band to band and it may be necessary to use maximum output from the generator before the image can be heard. Having set trimmer No. 8, remove the input and with the receiver set back to 490 on the dial tune trimmers 2, 4, 6, for maximum noise. Run the HRO dial from one end of the band to the other, when the noise output should remain fairly constant. If the volume varies markedly across the band poor *ganging* is indicated; with the HRO dial turned to about 20, use an insulated screwdriver handle to press the oscillator gang vanes gently towards the stator, noting whether the noise level rises or falls. If it rises, more oscillator inductance is required; if it falls, it is either tracking OK or it needs less induc-

tance. To prove which, repeat the test on the other gang sections and in particular the mixer grid section. If on trying this latter, the noise decreases, the inductance is correct; if it increases then the oscillator needs its inductance reduced.

Adjustment of oscillator inductance can be achieved in various ways. The literature says that for the two highest ranges (7·0-14·4, and 14-30 mc) a half-turn of the inductance is moved. Quote: "Bending this loop from right to left across the end of the coil form will increase the inductance." The writer has a 3·5-7·3 mc coil which is similar but the book says that these, and the 1·7-4·0 mc coils, are fitted with a brass disc which can be screwed into or out of the oscillator coil field, and this appears to be the normal arrangement for these ranges.

Some of the MW coils seen by the writer have a short-circuited turn of stout copper wire arranged to be adjustable as to its location relative to the winding, and this again appears to be usual—but the writer has also seen one where the adjustment was done in the same fashion as in the case of the 160/80 and 80/40 metre coils already mentioned. (It is suspected that the ones which are abnormal are coils which have been made to serve for other ranges by later conversion). On some of the low frequency coils trimmer No. 7 is used as a series padder and replaces the inductance adjustment but it should be noted that on the HF ranges trimmer No. 7 is used in connection with the bandspread facility, where fitted.

After each adjustment of inductance the process of setting trimmer No. 8 and then checking the noise across the band needs to be repeated; it will be found that the inductance adjustment is flat, in marked contrast to trimmer No. 8 which is very sharp, and is also pulled to some extent on the 14-30 mc coil by trimmer No. 6.

All this shows the need for great care in handling the 14-30 mc coil, and its trimmers. The correct position for trimmer No. 8 is when it is most anti-clockwise. But it is essential to apply the image signal check to be sure of the matter.

Adjusting the Bandspread Ranges

The first thing to be noted is that changes to the General Coverage adjustments will upset the Bandspread operation but the reverse does not hold true. In practical terms, this means that if you pick the wrong trimmer during adjustment of a Bandspread coil-setting you go back to the beginning and repeat the general coverage adjustment. Its just like Snakes and Ladders—pick the wrong one and Junior wins every time.

In practice, the first part of the exercise is to shift the screws from the left to the right-hand terminal block position as viewed from the front of the coil. From the calibration curve on the front, select the frequency corresponding to 450 on the dial, inject a signal at that frequency, and adjust trimmer No. 7 until the signal is tuned in. Slide down to 50 on the dial, and inject a frequency

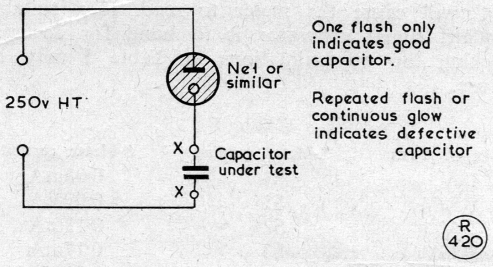


Fig. 2. A practical test circuit for estimating the goodness of fixed condensers, which should always be checked through in any surplus-type Rx, or in a receiver undergoing general overhaul. A straight DC continuity check on a test meter is not always a reliable guide.

at the LF band-edge which should appear at 50; if it does not then the series bandspread padder is called into play, by screwdriver adjustment through the rear of the coil box. A guide as to which way it should be is that if the band edge appears in the 0-50 region of the dial, the padder needs to be increased; if it is on the high side of 50, then it needs reduction. The setting is critical, and must be checked and repeated until the bandspread range follows the calibration curve to the desired accuracy.

The RF stage must now be set up. Inject a signal at 450 on the dial, and peak trimmers 1, 3, 5; this can as well be done on noise as signal if the input is disconnected from the generator. Turn the dial to 50, and again check these same trimmers; if the signal (or noise) goes up with further clockwise rotation of a trimmer, then the corresponding padder condenser must be increased and *vice versa*. These padders are adjusted, like the one in the oscillator box, through a hole in the rear of the revelant box. Padder adjustment upsets the trimmer setting, hence any coil set requires the whole procedure to be repeated several times so that the best possible setting is achieved.

The whole business sounds—and is!—tedious and longwinded, but it must be remembered that the full treatment is rarely necessary, unless the previous owner was a real "lid." The only HRO coil that this writer has ever met that was wildly out was a GC unit that was supposed to be u/s but turned out to be a good Bandspread coil after a complete re-alignment, and study of the book.

The S-Meter Circuit

Most HRO receivers seem to have the proper meter fitted except for the one in the writer's possession. The setting-up procedure is as follows: Disconnect the aerial, turn the AVC off and set the RF Gain to 9½, then adjust the potentiometer near the aerial terminals until the meter reads zero. This is marked as No. 17 on the manual front panel photograph. To make a measurement the AVC should be Off and the aerial disconnected momentarily, when the RF Gain may be rotated so that the meter reads zero; reconnection of the aerial and switching on the

AVC will cause the meter to read. If a suitable standard signal generator is to hand for accurate checking the approximations in Table I may be of use.

Table I

Input Volts	S-Meter reading	S-Meter current
1μV	S$\frac{1}{2}$	0·03mA
1·5μV	S1	0·07mA
2μV	S2	0·13mA
3·3μV	S3	0·17mA
5μV	S4	0·21mA
8μV	S5	0·25mA
10μV	S6	0·32mA
20μV	S7	0·38mA
35μV	S8	0·44mA
55μV	S9	0·5mA
170μV	S9 plus 10	0·6mA
500μV	S9 „ 20	0·7mA
1·6mV	S9 „ 30	0·8mA
5mV	S9 „ 40	0·9mA

If the S-Meter is not within striking distance of these figures after setting up as indicated above then the two resistors R11 and R30 which are selected on test can be adjusted.

Table II

TABLE OF VALVE VOLTAGES

Valve Function		h-h	g_1	g_2	g_3	a	k	d_1	d_2
1st RF	(a)	6·3	0	82	1·95	200	1·95	—	—
	(b)	6·3	0	77	1·9	200	1·9	—	—
2nd RF	(a)	6·3	0	82	2·0	200	2·0	—	—
	(b)	6·3	0	77	2·0	200	2·0	—	—
Mixer	(a)	6·3	0	62	2·45	200	2·45	—	—
	(b)	6·3	0	45	2·3	200	2·3	—	—
Local oscillator	(a)	6·3	0	82	0	200	0	—	—
	(b)	6·3	0	75	0	200	0	—	—
1st IF	(a)	6·3	0	78	2·2	180	2·2	—	—
	(b)	6·3	0	76	2·2	180	2·2	—	—
2nd IF	(a)	6·3	0	83	4·3	180	4·3	—	—
	(b)	6·3	0	80	4·5	178	4·3	—	—
Det/AF	(a)	6·3	0	143	0	0	0	0	0
	(b)	6·3	0	125	0	0	0	0	0
BFO	(a)	6·3	0	10	0	32	0	—	—
	(b)	6·3	0	10	0	25	0	—	—
Output	(a)	6·3	0	200	—	180	8·75	—	—
	(b)	6·3	0	200	—	180	8·75	—	—

Current drain of receiver HT varies between 38 and 57 mA at 200 volts, depending on setting of RF gain from min. to max.

NOTES:

(1) All voltages measured at the valve pins against chassis on 250v. DC range, except heater and cathode voltages measured on 10v. AC and 10v. DC ranges respectively,

(2) Ref (*a*) voltages are measured using 4000 o.p.v. meter, others using 1000 o.p.v. meter,

(3) All voltages measured with 6·35v. AC and 200v. DC, stabilised, connected to input,

(4) Test Conditions:—RF Gain Max.; AVC Off; BFO On; Selectivity peaked; Phasing at minimum; AF Gain at minimum; HT and S-meter On. Receiver dial set at 250 on the 0·9-2·05 mc range, and aerial terminals both disconnected.

NATIONAL HRO

Valve Pin Connections

Pin No.	6D6	6C6	6B7	42	6K7	6J7	6B8	6V6	
1	h	h	h	h	shell	shell	shell	shell	1
2	a	a	a	a	h	h	h	h	2
3	g_2	g_2	g_2	g_2	a	a	a	a	3
4	g_3	g_3	d_2	g_1	g_2	g_2	d_2	g_2	4
5	k	k	d_1	k	g_3	g_3	d_1	g_1	5
6	h	h	k	h	—	—	g_2	—	6
7	—	—	h	—	h	h	h	h	7
8	—	—	—	—	k	k	k	k	8
Top Cap	g_1	g_1	g_1	—	g_1	g_1	g_1	—	

The Crystal

If this is not very active and it is certain the alignment is true then the crystal may be removed and washed in carbon tetrachloride (Thawpit) before being reassembled in its holder, when it should have a clearance of 2-3 *thou.* in each direction. If the fibre packing pieces are still in place these can be removed as they were put in for transit only and serve no useful purpose.

Mechanical Matters

The HRO dial does not have back-lash! However, if back-lash does appear to develop, check the screws fixing the knob to the shaft. On the writer's HRO these slacken off on an average once a year, with nightmares for a couple of days till the penny drops. In fact the writer has never known one to give trouble apart from lubrication—but he has no lubrication or adjustment data. Any such information will be gratefully received.

Summary

It must be pointed out that all these suggestions are based on experience with the G3KFE receiver over a period of time, and from what bits and pieces of information the writer could pull from friends, and from various reprints which are believed to have originated from America. In Part II of this article it is proposed to discuss some modifications that can be undertaken to make the HRO more suitable for coping with 1965 conditions.

Editorial Note: To forestall enquiries, we regret to have to say that we cannot supply individual copies of the HRO Manual. However, there are plenty of them about, in the hands of readers, so that a loan-

ABOUT THE HRO RECEIVER

IMPROVING BFO INJECTION FOR SSB — REVALVING CONSIDERATIONS — BANDSPREAD COIL MODIFICATIONS — IDEAS FOR BETTER SELECTIVITY — TVI AND AERIAL COUPLING

Part II

E. P. ESSERY (G3KFE)

Anyone possessing an HRO—and there must be 1,000's of them in amateur stations up and down the country, to say nothing of the rest of the world—will realise on reading this second part of his treatment of the "National HRO" that our contributor has been into the receiver pretty thoroughly. The suggestions he makes and the modifications he describes amount to good practical information on a receiver which is basically very sound but can be made much better for amateur-band conditions as they are today. The first part of his article—dealing with checking performance, alignment and general servicing—was published in our issue for November last. A concluding instalment will appear in a later issue.—Editor.

THE essential data on the HRO circuitry and alignment were given in Part I, and here the intention is to consider what can be done with a war-surplus HRO in good running order, to bring it nearer the mark for use under modern band conditions—both as regards telephony and CW—and to try, where necessary, to discuss the underlying reasons that influenced the choice of circuits.

BFO Injection

There was a theory some years ago, which gained wide acceptance, suggesting that BFO injection should be kept to a minimum. The effect of this was to enforce the use of a low RF/IF gain control setting to get a clean beat note out of the speaker—which, quite as a side issue, dictated a control setting that made the best of the IF selectivity. Further, the low level of BFO injection reduced the degree of screening needed to bring spurious signals due to BFO harmonics down to an acceptable level, making the receiver cheaper to manufacture. The advent of SSB immediately showed up the weaknesses of such receivers—and in fact demonstrated the lack of progress in design over a period of 20 years.

In order to receive SSB one has to re-insert the missing carrier at the receiver; the level of carrier injection must be enough to make the reconstituted signal look as though it were not modulated more than 100 per cent. Hence, if there is not enough BFO injection there will be more Sideband than re-inserted carrier and the signal as resolved will not be readable. There is a simple solution to this, involving the shunting of the 2 $\mu\mu$F injection condenser by a further 22 $\mu\mu$F, making C33 in the circuit on p.659 up to 24 $\mu\mu$F.

In all modern receivers one will find a product detector, together probably with a special injection oscillator; however, before you dive into the inside of the HRO and fit one, let the writer remark that in no case where a product detector is compared with a *diode detector* and *adequate* BFO, over a period of months, has any *practical* advantage been found to accrue. In no case was a signal readable on the one that was not equally readable on the other, and in the HRO the possible slight advantage of the product detector in terms of lower distortion is lost in the overall distortion produced in the rest of the receiver, which is still acceptable for communications purposes.

The only problem then is to find the 2 $\mu\mu$F capacitor, C33, and in fact it will be found to look more like a tagstrip than anything else; the easiest way to find it is to trace back from the circuit into the receiver until you find the "tagstrip."

BFO Alignment

When the BFO is aligned in the manner called for in the HRO manual, the BFO is aligned to the receiver IF when the BFO knob is set to position 9. A better setting for general use on the amateur bands is with the BFO set to the receiver IF when the control is set to posn. 5. This can be achieved by setting the receiver to the condition of absolute maximum selectivity, centring a signal in the middle of the passband, setting the BFO to posn. 5, and then adjusting the BFO trimmers to give zero beat with the signal. In this manner a BFO range of ± 5 kc can be achieved. When this has been done, SSB reception will be obtainable with a BFO setting at about 2-3 or 7-8; phasing at about 5; and Selectivity peaked, once again around 5. A trial on 80m., where most of the SSB signals are on LSB, and on 20m., where the majority are on USB (in accordance with the convention), will soon find the exact settings. The reception of SSB in this manner is done with the AVC switched *off*, the audio wound up to near maximum and the lowest possible RF gain control setting.

Power Pack

It will very soon be found that the receiver is prone to drift, even after warm-up, and that there is a tendency for the RF gain to shift the frequency; this latter is even more noticeable if the HRO is used with a transmitter and muted by lifting the RF and IF stages cathode line above earth on "transmit," which seems to produce a slow drift during transmission, followed by a drift back again during reception periods—which is very disconcerting and productive of lost QSO's. The usual ploy is to provide a stabilised line for the local oscillator and the BFO, which helps a lot, but the accident of having a fully stabilised supply on the bench at a time when the

FOR THE RADIO AMATEUR AND AMATEUR RADIO

The SHORT-WAVE Magazine

EDITORIAL

Outlook *It is generally supposed—because somebody says so in print—that "the maintenance of the amateur position depends upon a united front."*

Really, it depends on nothing of the sort. It depends upon the fact of there being a sufficient number of amateurs interested in communication on a world-wide basis. Taking the world as a whole, there are now about 400,000 such stations, each individually owned and each with a stake in the continuance of the freedom of the ether, subject to reasonable safeguards acceptable to all.

The more active organisations there are, within the general framework of Amateur Radio, working towards the same end—the safeguarding of the position in our bands—the better. Far more can be done informally behind the scenes than formally at the conference table.

In the sophisticated and civilised Western world, there is no particular "danger to Amateur Radio" in the sense of losing frequencies by legislation. No modern country under-estimates the value of its radio amateur population. But the less advanced countries—which are, broadly, the emergent states of Black Africa and some other parts of the world—have a totally different outlook, because they are as yet unable to grasp what Amateur Radio means and to see where it can have advantages for their own development.

In the West, it is now hardly possible, administratively or logically, to eliminate Amateur Radio merely by legislation. For one thing, there are far too many individuals involved, each with a capital investment worth anything from £20 to £20,000, and for another there is among all these thousands a sufficient number who would be prepared to defy what they would regard as unjust and unreasonable law—and it would take years to bring their cases before the courts.

What, then, is really the problem facing Amateur Radio? It is the constant and continuing encroachment on the amateur bands by pirate commercial stations flouting the 1959 Geneva regulations. Certain irresponsible administrations are simply grabbing frequencies to suit themselves in band areas which appear to be under-loaded or lightly occupied, fully in the knowledge that practically nothing can be done officially to move them out.

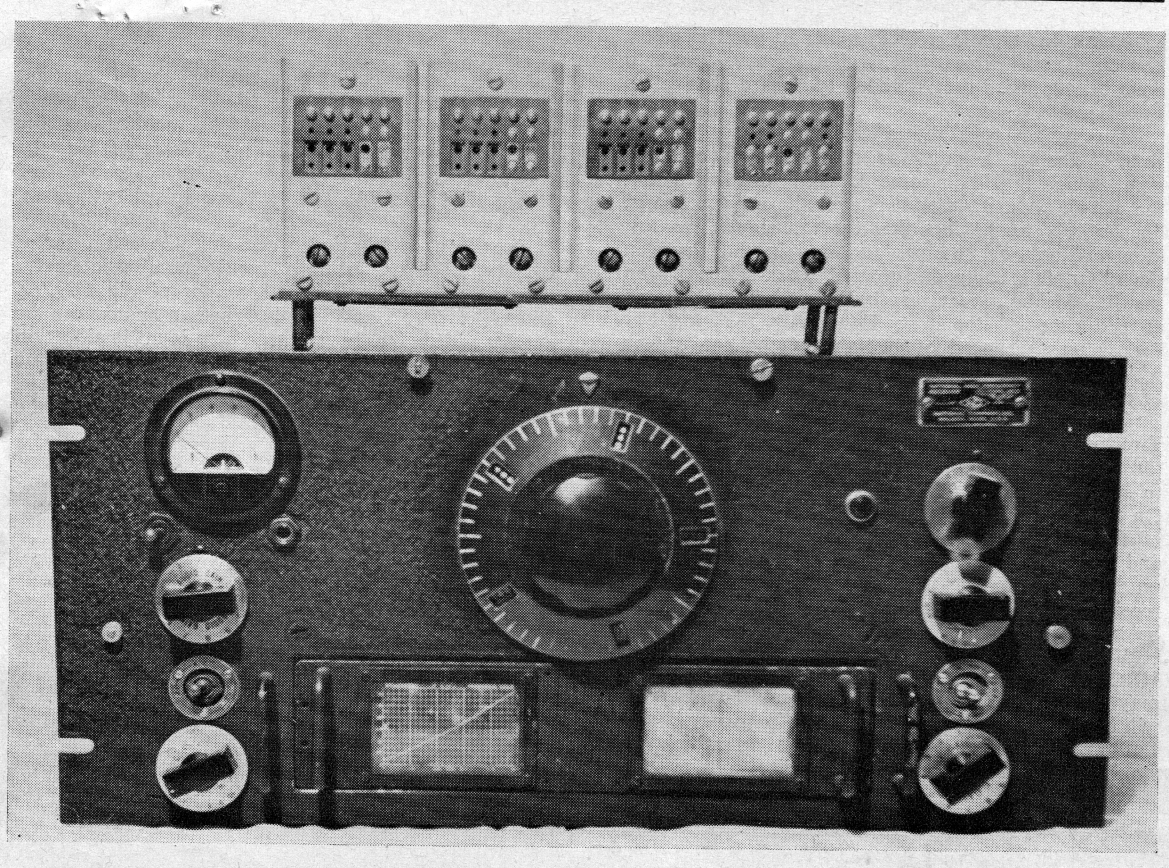
Accepting, therefore, that this is the real danger—and it has been prognosticated in this space for years—it follows that "presenting a united front at any international conference" is not nearly so important as bringing pressure to bear (in whatever ways may be possible) on these irresponsible administrations.

So long as this is done, it does not matter how or by what means the indoctrination process is carried out. It can probably be achieved more effectively by small but influential groups acting privately than by relying solely on what is called "presenting a united front at official conferences."

And, anyway, in this latter context, it is the quality of our representation that is of prime importance.

Austin Forsyth, G6FO.

WORLD-WIDE COMMUNICATION



Front-panel appearance of the HRO receiver—in this case the rack-mounting model, using the side slots. The tuning dial is a very neat mechanical contrivance which allows for a high degree of re-setting accuracy, particularly when the bandspread coil packs are used. The coil set standing on the receiver is a bandspread unit and — following G3KFE'S text — the trimmers to which he refers are Nos. 1-8, reading from left to right. The Rx as shown here is fitted with another coil pack — along the bottom, with the appropriate dial calibration in the window on the left — and the panel levers are to enable the coil pack to be squeezed out while not disturbing the position of the receiver.

HRO pack was out of action, very soon convinced the writer that the fully stabilised power pack is a *must* for the best results—which is rather obvious when one realises that the HT drain of the receiver varies between 40 and 60 mA at a constant 200 volts from the stabilised pack. If the HT is not stabilised the conditions into which the oscillators look change with every shift of the controls, the circulating current in the oscillator coils is continually varying and hence changing the temperature of the windings, so the heat distribution in the cabinet is also changing, and so on. Not all of these changes are quick acting, and so the receiver is constantly drifting to a greater or lesser extent. Stabilising the entire HT is simple and easy, and coupled with reasonable attention to ventilation by leaving the lid open a quarter-inch or so in the case of a table model (and a few judicious holes in the lid of a rack model) will work wonders with any HRO. But it is no good then piling a load of papers on top of the receiver to stop it getting cold! A suitable power unit is shown in Fig. 1, and has a lot of other handy uses around the shack which make it always a useful piece of gear.

Revalving

There must be more utter drivel talked in radio clubs, by people who ought to know better, about the revalving of war-surplus receivers than almost anything else. There seems to be an idea that a miniature valve is in some way better than an octal valve or a UX-based one, and will ensure that magically the receiver will hear more DX and sound more "lively." This is dangerously far from true.

The factors that affect a receiver's ability to hear a weak signal are functions of selectivity, sensitivity, and signal-to-noise ratio, and stability. The first and last are not connected with the valves to any serious extent, the other two being very much inter-linked with each other, and with the valve behaviour.

It may be said that the receiver front-end does not come into the picture at all on the 160, 80 and 40 metre bands due to the high level of noise picked up on these bands by the aerial, some of it being natural and some of it man-made at the average QTH. Very little can be done about it, and the result is that no RF stage is necessary in front of

a war-surplus type (*e.g.* 6K8) mixer in good circuitry and condition—as many R.1475 users have found to their benefit when they modded the guard channel to Top Band.

The writer once did a test comparison of the R.1475 against a post-war receiver with one RF stage, which is still in some demand, and found that the R.1475 won hands down over the other receiver, due entirely to the fact that the test signal was lost in QRM on one receiver and was in the clear on the other, this being due to the better selectivity on the R.1475, both receivers being well up to scratch at the time of the test. Eventually the post-war beauty was disposed of because of the consistency with which it failed to produce the signals in spite of its little glass valves.

This argument ceases to be quite so true on Twenty, where the noise level on the aerial is often lower, and the receiver has to be a lot more sensitive to hear signals only a little above the aerial noise. On Fifteen and Ten, it is fair to say that for most of the time there is virtually no noise on the aerial, and then we have reached the condition that arises on VHF, where the noise in the first stage of the receiver is the limiting factor, and all efforts must be turned to this end.

Thus we are saying that the receiver, if it is an HRO in good condition, will not miss anything that may appear between Top Band and Twenty, but will be a bit poor on the two higher-frequency bands. But wait—these are just the bands on which we would like to have some more stability, so a crystal-controlled converter is a must in any case.

There is still another consideration, and that is the matter of cross-modulation, which is very apt to occur with the short grid-base of the high-gain low-noise valve types, of which, incidentally, the best of the bunch by far until very recently was the 6AC7, at least in the area below 30 mc that we are considering. The 6AC7 is on the despised octal base, too !

Now we can begin to see that the main factor is going to be a question of band operating interests ; local QRM which often is a matter of old G3XYZ down the road ; and simply whether spares can be got for old valves. In general, there is no justification in revalving a receiver in good condition. If the valves *are* down and replacements are not obtainable, then the selection of new ones should be on the

Table of Values

Fig. 1. Stabilised PSU for the HRO

C1, C2 = 16 μF, 500v. DC wkng., elect.
R1 = 100 ohms
R2 = 470,000 ohms
R3, R5 = 10,000 ohms
R4 = 22,000 ohms
R6 = 82,000 ohms
RV1 = 20,000-ohm 5w. linear pot.
Ch.1 = 10 Hy. 120 mA choke
T1 = 350-0-350v. 120 mA, 5v. 2A, 6·3v. 2A, 6·3v. 4½A.
V1 = GZ32, or equiv.
V2 = 6L6G, or KT66
V3 = EF80, or equiv.
V4 = VR-105/30, or equiv.

Note: All fixed resistors are one-watt rating to 20% tolerance. Iron-cored items Ch.1 and T1 should be rated for continuous running.

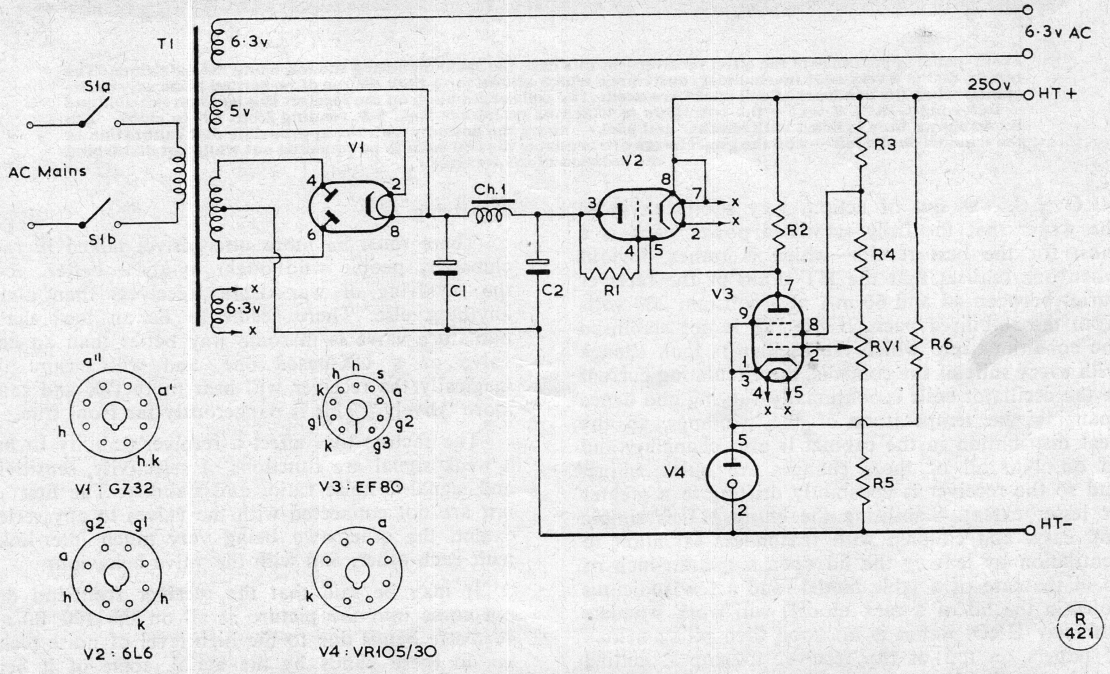


Fig. 1. Circuit of a stabilised power pack for the HRO. This will take care of the wide variations in current loading with shifting of the controls (see text). Besides this, such a PSU is in itself a very useful piece of equipment to have on the bench. To set up the pack for any HRO, potentiometer RV1 is adjusted to give 250v. output with the Rx connected and warmed up.

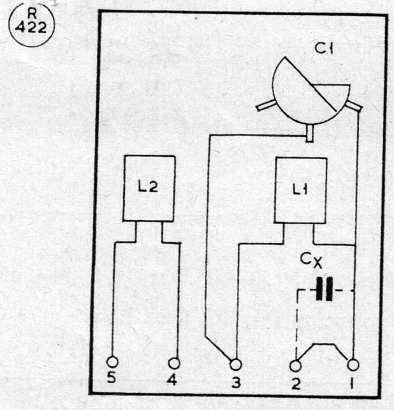


Fig. 2A. RF and mixer coil modification for bandspread. On Top Band condenser Cx should be 33 $\mu\mu$F. For other bands, Cx is the bandspread padder, variable preset, calculated as given in the text. Wiring changes involve removing the link between points 1 and 2 and paralleling Cx as shown, L1/L2/C1 being existing components.

consideration of getting the best possible cross-modulation characteristics unless all operation is on Twenty and there are no locals near enough to give trouble. In this case the first RF can well be a 6AC7 with a higher value of screen resistor than is usual to give as much protection as possible against cross-modulation. If supply problems force one to revalve then possibly the 6BE6 and 6BA6 series are the best ones to go for. But before cutting into the receiver it is suggested that tests be made with an adaptor consisting of a suitable valve base wired to an octal or UX plug as the case may be, followed by realignment and a period in service. Accurate measurements will show that most cases of revalving to "hot up" the HRO in fact degrade the performance and only very rarely will any significant improvement occur in comparison with an unmodified receiver in good condition. Most spectacular improvements after revalving result from the (accidental) clearing of faults !

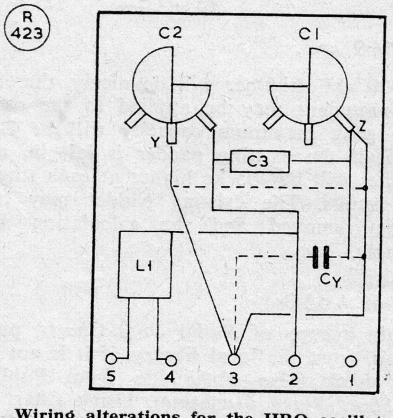


Fig. 2B. Wiring alterations for the HRO oscillator. The changes are to remove the links between points Y and 3, and Z and 3 ; connect Y and Z ; and parallel Cy across points 3 and Z. For Top Band Cy is 33 $\mu\mu$F ; on other bands, Cy is a bandspread padder. Existing components are L1, C1, C2, C3. See text.

Bandspread

The possession and use of the bandspread coils in the HRO are a boon which no other receiver giving general coverage can match. However, a set of bandspread coils is a rarity, and to buy would cost more than the receiver is worth. We must therefore make them for ourselves—which is quite possible, if we first consider the principle involved.

A bandspread coil can be identified by looking at the contact block carrying the pips which mate with the fingers in the actual receiver, which appear on the topside of each of the four boxes making up the assembly. In front of each of the pips there is a recess in the moulding which may or may not be filled with a small piece of metal. If the piece of metal is tapped for a countersunk screw in two cases on each block, and a screw is in one of each pair but not the other, then you have a bandspread coil. They are made for 1·7-4·0 mc (BS80) ; 3·5-7·3 mc (BS40) ; 7·0-14·4 mc (BS20), and 14·0-30·0 mc (BS10). Looking at one of these bandspread coils from above with the calibration graphs facing you, the screws are in the left-hand position on each contact block to give normal coverage ; shifting the screws from the left-hand position to the vacant right-hand hole on each block will give the bandspread condition.

What do these magic screws do ? In fact it is all very simple, and all that happens is that the screw in the left-hand hole shorts out a padder capacitor which reduces the effective swing of the tuning gang, while the absence of the screw in the other hole disconnects the trimmer provided to bring the other end of the bandspread range into line. Hence, the statement that an adjustment of the general coverage alignment will upset the bandspread but not the other way about.

Let us first of all consider the creation of a Top Band bandspread coil from a 0·9-2·05 mc coil. The method is due to G3NEE, and was published in the Southgate Club "Newsletter" in July, 1962. In Fig. 2A here, replace the link between tags 1 and 2 by a 33 $\mu\mu$F 1 per cent silver mica capacitor, Cx. In the Oscillator section (*see* Fig. 2B) the links from Y to tag 3, and from Z to tag 3, are removed, and Y is then linked to Z. The link Y-Z is then joined to one end of another 33 $\mu\mu$F similar condenser Cy, the other end of which is joined to tag 3. Re-assemble and carry out a re-alignment, padding the oscillator with the No. 7 trimmer, as shown in the previous article, and trimming with the No. 8 trimmer, to get nice bandspread of Top Band. The RF stages are trimmed with the ex-GC trimmers, juggling things till a nice even gain is obtained over the band consistent with the desired spread.

Looking at the circuit on p.658, which shows a receiver with a bandspread coil plugged in, a pair of points marked 1 and 2 will be seen in the grid circuit of the first and second RF, mixer, and local oscillator valves respectively ; in the bandspread condition, the pair marked 1 will be linked in each

case, and in the general coverage case the screws will be linking the points 2, and a few moments consideration will show that in each case, the shorting of the points 2 by the screw will short out a trimmer, which is the thing we have regarded as a bandspread padder.

Making Bandspread Coils for the HRO

In the first instance let us disregard Top Band, which we have already dealt with, and concentrate on the method of converting a general-coverage coil. In each case, it will have been noticed that the bandspread area is located at the HF end of the general-coverage range. *This is fundamental* to the working of the system. Now, if we are prepared to adjust the existing parallel trimmer, (*i.e.*, the GC one), then our problem will resolve into a matter of calculating the approximate value of the bandspread padder, and fitting an appropriate trimmer in the places where G3NEE put his 33 $\mu\mu$F in Figs. 2A and 2B, other wiring being as per these two sketches.

Let us look at the calculation for a conversion of a 40-20 GC coil to bandspread 20 metres.

The gang swing is 10 to 225 $\mu\mu$F
Valve capacity, say 15 $\mu\mu$F
Circuit strays, say 10 $\mu\mu$F
Main trimmer, say 15 $\mu\mu$F (about mid-setting).

Hence, the RF gangs will swing from 50 to 270 $\mu\mu$F in their GC role. This will not apply to the oscillator gang, due to the presence of the padder, in this case 0·0026 μF.

The standard formula for two capacitors in series is :

Eq.1 $C_{TOT} = \dfrac{C_1 . C_2}{C_1 + C_2}$, where C_{TOT} is the resultant, and C_1 and C_2 are the two capacities.

Re-arranging, we get :

Eq.2 $C_2 = \dfrac{C_{TOT}\ C_1}{C_1 - C_{TOT}}$ which we will soon need.

Now, putting in values into *Eq.1* appropriate to our oscillator circuit and a 40-20 GC coil, we get :

$$C_{TOT} = \frac{C_1 . C_2}{C_1 + C_2}, \quad i.e. \frac{225 \times 2600}{2825} = 208\ \mu\mu F$$

that is, the oscillator gang maximum has been reduced from 225 to 208 $\mu\mu$F, and hence the total swing, assuming the same strays as for the RF gangs, becomes 50 to 253 $\mu\mu$F.

We now have to find the value of the inductance in each case. This we can do by means of a set of ABACs, or by calculation; let us firstly look at the calculations, and then at the method using the ABACs which are available either in the Public Library or possibly in the shack.

$\omega L = \dfrac{1}{\omega C}$, as we learned in the R.A.E.

Whence $L = \dfrac{1}{\omega^2 C}$ where $\omega = 2\pi f$, f being frequency, *i.e.*, $L = \dfrac{1}{4\pi^2 f^2 C}$ ———*Eq.3*

Now, C is 50 $\mu\mu$F when f is 14·4 mc, and assuming $\pi^2 = 10$. Then $L = \dfrac{10^6}{4 \times 10 \times (14{\cdot}4)^2 \times 10^6 \times 10^6 \times 50 \times 10^{-12}}$

$= 2{\cdot}4\ \mu H$.

By the same argument as for *Eq.3* we may say that $C = \dfrac{1}{\omega^2 L}$ ———*Eq.4*

Let us say we want the bandspread to have an LF limit of 13·9 mc, to give us a bit of leeway, then this frequency must occur when 2·2 μH is resonated with some capacity, found from *Eq.4*. Call this C_t. Then :

$$C_t = \frac{10^{12}}{4 \times 10 \times (13{\cdot}9)^2 \times 10^{12} \times 2{\cdot}4 \times 10^{-6}} =$$

54 $\mu\mu$F. Of this 54 $\mu\mu$F we know that about 40 are already in the circuit as strays, so our bandspread padder will need to reduce the 225 $\mu\mu$F maximum capacity of the gang to 14 $\mu\mu$F.

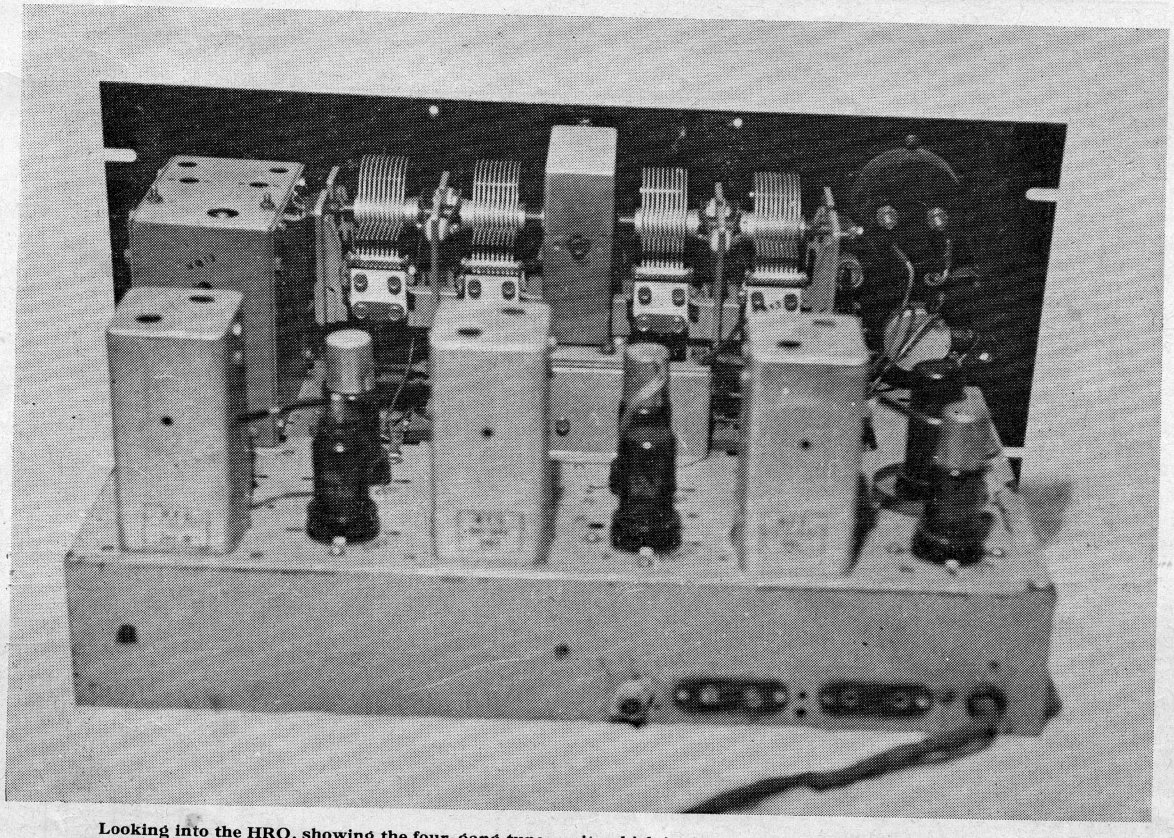
From *Eq.2*, $C_2 = \dfrac{C_{TOT}\ C_1}{C_1 - C_{TOT}}$, *i.e.*, $\dfrac{225{\cdot}14}{225 - 14}$

$= 14{\cdot}9\ \mu\mu F$.

A 3-30 $\mu\mu$F trimmer will do nicely, therefore. A similar argument may be applied to the oscillator, but the gang maximum capacity will be 208, not 225 $\mu\mu$F, if the existing padder is left in, and the frequencies will be 455 kc higher at each stage, with similar results. The existing padder may in most cases be removed and the calculation adjusted accordingly.

By Use of ABACs

Obtain a copy of *Radio Data Charts*, published by Iliffe's, from the local library, if it is not already in the shack (also obtainable from Publications Dept., *Short Wave Magazine*). Using Chart No. 2, to be found on p.9, headed "Inductance, Capacity, and Frequency—Short Wave" project from 253 $\mu\mu$F, through 7·0 mc to the inductance line; likewise from 55 $\mu\mu$F through 14·4 mc to the inductance line.



Looking into the HRO, showing the four-gang tuner unit, which is the great feature of this receiver. It is this excellent mechanical arrangement which, combined with plug-in coil packs, makes the National HRO so effective as a general-coverage and amateur-band receiver. Though the octal-based valves used (see text) are regarded as obsolete by modern standards, as explained by G3KFE in his article there is no real need to replace them unless they are down on emission or are otherwise faulty. If the set is in good order, the front-end gain will be adequate on the LF bands.

The two projected lines should meet at about 2·2 μH. If they don't, assume the inductance to be in the middle of the space between the lines you have projected. Back-project from the inductance so found, through 13·9 mc to find the new value of total max. C, deduct the 45 $\mu\mu$F for strays and apply Formula 2 to get the nominal value of the bandspread padder capacitor. Don't forget that the oscillator calculation is exactly the same *except* that the frequency is always 455 kc higher than the signal frequencies. We find that the ABAC gives us a C at 13·9 mc of 58 $\mu\mu$F and hence the nominal value for the bandspread trimmer of 14·9 $\mu\mu$F as before. Likewise for the oscillator.

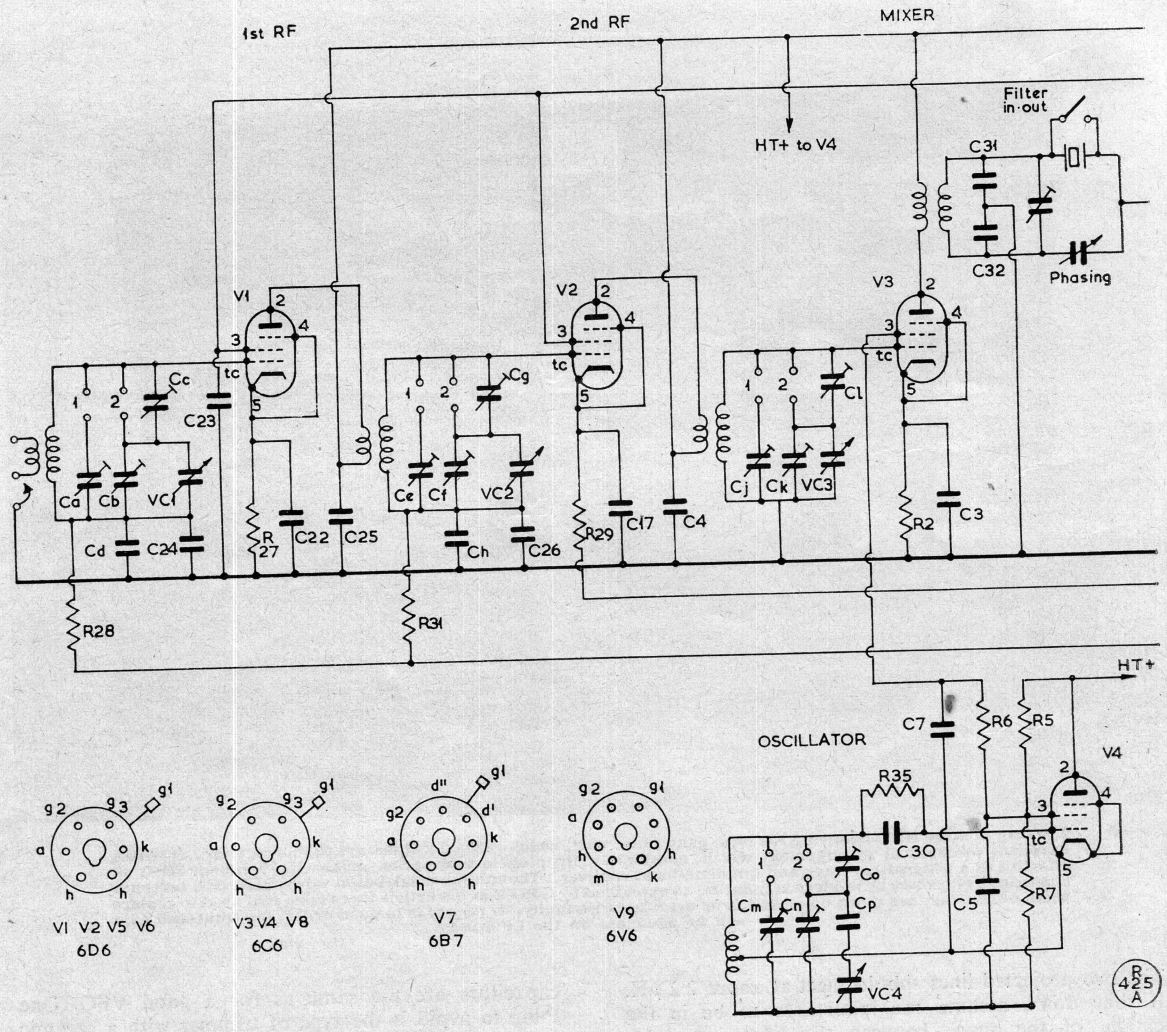
Coil Modification

Now to the practical work. The first thing to do is to install trimmers of the desired value ; probably the best sort of trimmer to use would be one of the same type, cannibalised out of an old LF band coil, if necessary pruning off a few vanes with great care. If these trimmers are not available, then one will have to scratch about a bit to find suitable ones which can be adapted to the purpose. The *criteria* for these capacitors are the same as for a good VFO. One thing to avoid is the type of trimmer with a ceramic end plate and aluminium vanes, as sometimes found in American surplus. Similar ones with brass vanes are sometimes available and seem to be much better. The trimmers should be mounted in such a manner that they can be adjusted with the coilset in the receiver, either by using the hole provided in the top face for the bandspread trimmer, or through the back of the coilset. The latter method involves the provision of a suitable hole in the receiver metalwork to mate.

Wiring is similar to that given in Fig. 2A and Fig. 2B ; the subsequent adjustment is similar to that of a normal BS coil, but using the new trimmer as the bandspread padder and trimming with the general coverage trimmer.

Bandspreading the 21 and 28 mc Ranges

This is best *not* done by modifying a normal coil as it will be found that the stability still leaves something to be desired. It is suggested that these two ranges be covered by means of a crystal-controlled converter, working into the HRO on some



non-amateur band as the tunable IF. Apart from anything else the *National* HRO coils for the ten-metre band are designed on a different basis and there will be complications in the calculations; however, if a CC converter is used—such as the one in the *Amateur Radio Circuits Book*, p.12; the *Amateur Radio Handbook*, p.423; the *ARRL Handbook*, 1963 Edition, p.127—and arranged to cover a tunable IF of 5·0 to 5·5 mc, then it only remains to provide a suitable bandspread coil for the HRO. It is suggested that the tunable IF be as suggested here, *i.e.* a 500 kc swing, so that Ten is covered in four "bites," rather than attempt to get a tunable IF of, say, 5-7 mc, as the gain of the converter is liable to be uneven, and in any event not enough spread for SSB will be available.

(To Be Concluded)

Table of Values

C1	= 1st IF heater by-pass	= 0·1 μF, 400v. DC
C2	= 1st IF grid filter	= ·01 μF, 600v. DC
C3	= Mixer cathode decoupling	= 0·1 μF, 400v. DC
C4	= 2nd RF HT decoupling	= 0·1 μF, 600v. DC
C5	= Local Osc. screen decoupling	= 0·1 μF, 600v. DC
C6	= 1st IF cathode decoupling	= 0·1 μF, 400v. DC
C7	= Local Osc. cathode to Mixer screen	= ·01 μF, 600v. DC
C8	= 1st and 2nd IF HT decoupling	= 0·25 μF, 600v. DC
C9	= 2nd IF grid decoupling	= ·01 μF, 600v. DC
C10	= 2nd IF cathode decoupling	= 0·1 μF, 400v. DC
C11	= 6B7 cathode decoupling (elect.)	= 10 μF, 50v. DC
C12	= 6B7 diode filter	= 100 μμF, 1000v. DC
C13	= 6B7 diode filter	= 250 μμF, 1000v. DC
C14	= 6B7 diode to AF gain control	= 0·1 μF, 400v. DC
C15	= 6B7 diode decoupling	= ·01 μF, 600v. DC
C16	= 6B7 pentode anode decoupling	= 500 μμF, 1000v. DC
C17	= 2nd RF stage cathode decoupling	= 0·1 μF, 400v. DC
C18	= 6B7 pentode anode to output grid	= 0·1 μF, 600v. DC
C19	= Output stage cathode decoupling	= 10 μF, 50v. DC
C20	= BFO heater decoupling	= 0·1 μF, 400v. DC
C21	= BFO screen decoupling	= 0·1 μF, 400v. DC
C22	= 1st RF stage cathode decoupling	= 0·1 μF, 400v. DC
C23	= Common screen decoupling, RF/IF stages	= 0·1 μF, 400v. DC