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THE AMATEUR RADIO RETAILERS ASSOCIATION

THIS YEAR AT

DONINGTON PARK

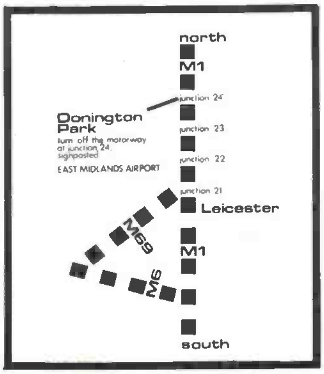
HOME OF THE DONNINGTON MOTOR MUSEUM

THURSDAY 29th OCTOBER
FRIDAY 30th OCTOBER
SATURDAY 31st OCTOBER

Open from 10 a.m. to 6 p.m.

Admission £1.00
(PARTIES OF 15 OR OVER 80p/PERSON)
Includes admission to the motor museum

NOTE CERTAIN DEALERS WILL BE REFUNDING ADMISSION COSTS ON SALES OVER £30.00



NOT AT LEICESTER

THIS YEAR AT DONINGTON

welcome to Donington

In 1971, following two or three years with no national amateur radio shows, a group of concerned dealers got their heads together and formed an association with the sole aim of putting on a really representative amateur radio exhibition in the Midlands. The result was the formation of the A.R.R.A. and the first National Amateur Radio Exhibition at the Granby Halls in Leicester.

Everyone now knows that the show went from strength to strength over the years, but in our tenth year it is obvious from comments received from visitors to the show that serious drawbacks arose as the attendance figures increased.

You will remember with horror, the state of Granby Halls at last year's show. No one could be content with such a place and we are delighted to tell you that the show has been moved this year to a superb new site at Castle Donington. All the problems of Leicester have been overcome by the move, and you will no doubt see the wisdom and necessity for leaving Granby Halls behind us.

how to get there

Access to Donington is easy. Simply leave the M1 motorway at exit 24 (East Midlands Airport) and follow the signs to Donington Park. You need only travel about a mile and a half along quiet country roads; quite a contrast to fighting with Leicester city centre traffic.

parking

Parking. You remember the parking in Leicester? At Donington Park there are 2½ acres of free parking right at the exhibition hall entrance. Say no more.

facilities

Cleanliness. The main complaint by visitors and exhibitors alike. When you pass through the plate glass doors, cross the carpeted entrance hall and enter the well lit, clear, warm halls at Donington, you will be amazed at the difference. Facilities in general. Clean toilets and a well staffed permanent restaurant will be quite a change from Leicester, where you needed wellington boots before you dared venture into the toilets.

for you

At Donington, all the main dealers and importers will be putting on an even bigger and better display of all the best for the Radio Amateur and Enthusiast. The only complaint is likely to be from wives and girl friends who may miss the stands selling dolls, balloons and souvenirs. The A.R.R.A. felt that these stands were not in keeping with Amateur Radio and, accordingly, have not allocated them space.

plus

Add to all this the fact that since the new exhibition is taking place at the home of the Donington Motor Museum, and the entrance charge also includes entry to the Museum, you have full and free access to the one of the finest collections of historic motoring in the country.

CIRCUIT OPERATION AND ALIGNMENT OF THE FRG-7 RECEIVER, PART I

INCLUDING A SIMPLIFIED ANALYSIS OF THE OPERATION OF THE DRIFT-CANCELLING BARLOW-WADLEY LOOP

J. L. LINSLEY HOOD, MIEE, MIMC

THE Yaesu Musen FRG-7 remains one of the most popular of the medium price range general coverage communications receivers, and its general method of operation is typical of a number of similar receivers based on the drift-cancelling oscillator arrangement known as the Barlow-Wadley loop. However, I have noted, with some regret, that those of my frineds and acquaintances who own receivers of this type tend to regard them as 'black boxes' whose insides are both complex and sacrosanct, and view the possibility of an improvement in their alignment — should circumstances suggest that this might be useful — as an undertaking only to be attempted by the foolhardy or the extraordinarily well equipped.

I feel that this is a pity for several reasons. Firstly because I think that a good understanding of the ·vay in which a piece of equipment works can help to increase one's enjoyment in its use; secondly, because without that understanding, and some minimum items of essential equipment which might be borrowed for the occasion, it would be quite unwise to poke about inside such an instrument; and thirdly because the accurate alignment of a receiver of this type, even with the appropriate equipment, is a job which will, inevitably, take several hours — so, on the production line, it is not going to be done as accurately, in every case, as one might wish. Finally, there are several things which can be done to improve the usefulness of such a receiver, ranging from the fitting of an external frequency counter, either of commercial origin or a DIY design, of which several have been described recently, to an improvement in the IF selectivity. None of these

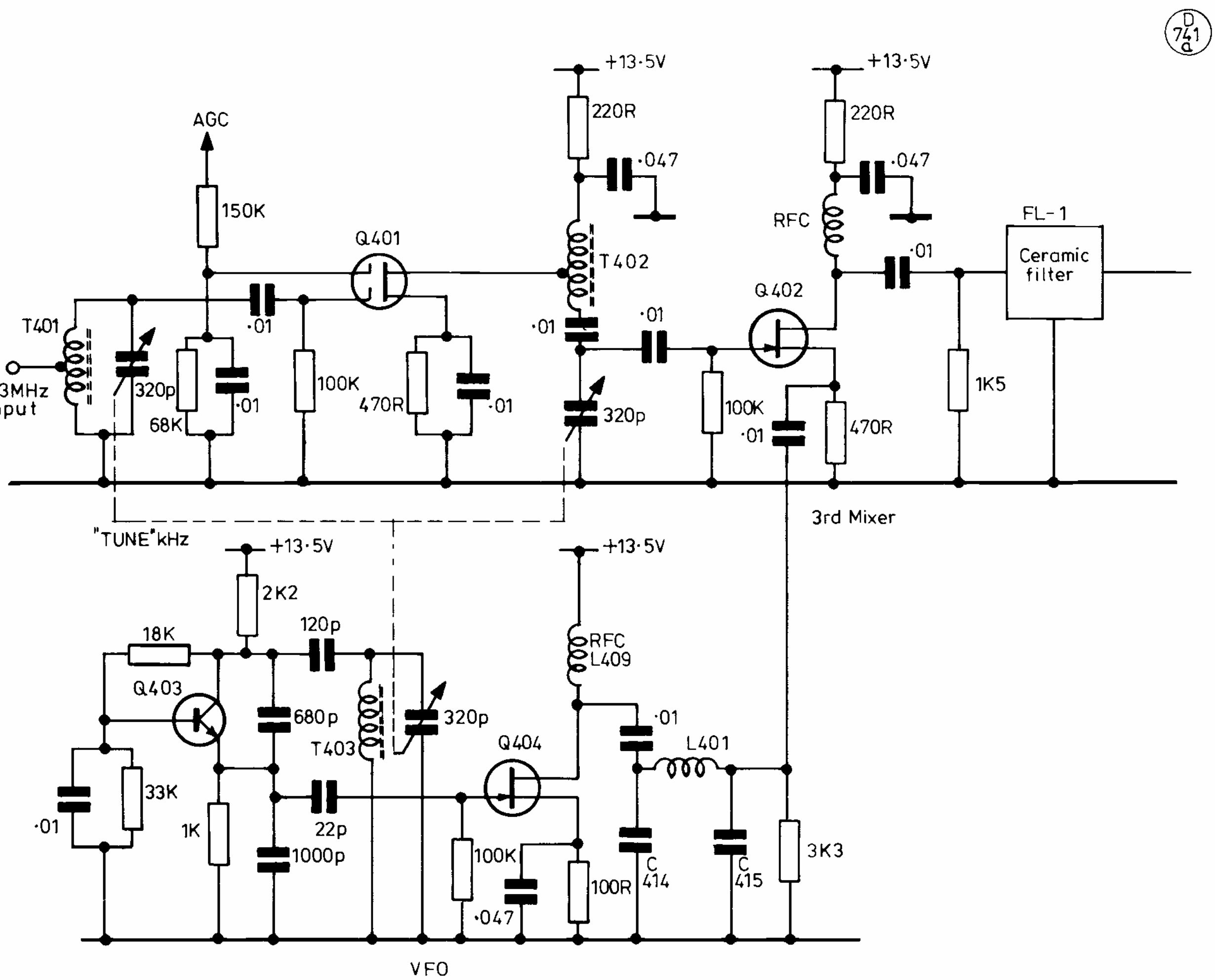


Fig. 1 THE "kHz" TUNED STAGE OF THE F.R.G.7. (Second and third IF's and audio output)

things can be done with ease or confidence if the circuit operation is not clearly understood.

Circuit Operation

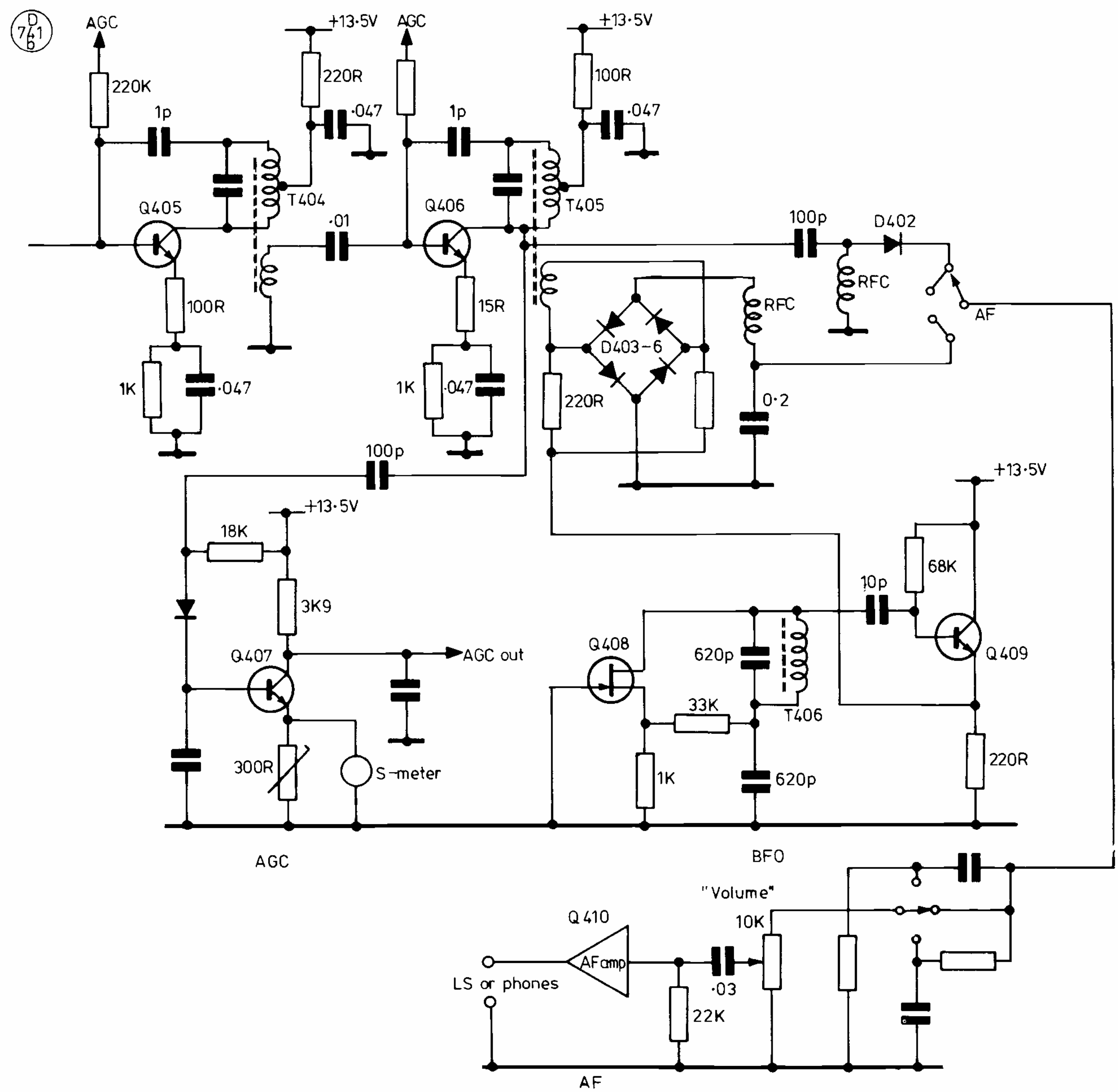
In the owner's manual, the makers describe the FRG-7 as a triple conversion superhet, using a synthesised heterodyne oscillator. Although the subsequent circuit description is both accurate and concise, it does not add much to the bare bones of that initial description, nor does it encourage the owner to take the circuit diagram in hand and make a conducted tour through the design. This omission I hope to remedy.

To begin with, I think it is helpful to regard this receiver as two separate parts. These are a conventional superhet, with one RF stage and two 455 kHz IF stages, covering the frequency range 2-3 MHz, and a preceding double-coversion RF unit, in which a 1 MHz wide slab of signals is converted up in frequency from the incoming 'aerial' frequency to the band 54.5-55.5 MHz, and then down again to the 2-3 MHz pass band to which the second half of the receiver is tuned. The double conversion, upwards and downwards in frequency, allows the drift cancelling feature of the Barlow-Wadley loop, but it does carry a penalty, which will be considered later. Since the second part of the receiver is the easiest part to follow, and the one in which the user may wish to make mods., I propose to take this bit first.

The general layout of the circuit is shown in Fig. 1, in a simplified form, but with the component numbers used by Yaesu appended where appropriate. This uses a dual-gate MOSFET, Q401, as the RF stage, a junction FET, Q402, as the frequency changer, and a bipolar transistor, Q403 as the tuned oscillator stage. The oscillator is followed by a junction FET buffer, Q404, which is used to inject the oscillator signal into the source of the FET mixer, Q402. A low-pass filter, L409, C414, C415 and L401, is used to remove any second harmonic from the output of the oscillator, which might give rise to spurious signals.

The first 455 kHz IF stage, Q405 is shunt fed from the mixer through a ceramic filter, FL-1, with a pass-band of about ±4 kHz at −10dB, in the interests of obtaining the selectivity required as far forward in the circuit as possible, to minimise cross modulation. The two 455 kHz IF stages, Q405, Q406, are conventional, neutralised, bipolar transistor tuned amplifier stages, with a choice of demodulators fed from Q406.

For normal AM reception, a diode detector, D402, is fed directly from the collector of Q406, although a peak-limiter diode, D407, may be switched into circuit for automatic impulse



noise reduction. However, for suppressed carrier USB or LSB operation an FET oscillator, bipolar buffer combination, Q408, Q409, can be switched into use. In this case the audio signal is taken from the output of the 'ring modulator' which consists of the diodes D403-406.

A normal integrated circuit AF amplifier, Q410, is fed from the demodulator selector switch *via* a very simple high-pass/low-pass filter switch and the volume control VR1. This will operate either an internal or external LS or phones.

HT supplies for the receiver are provided from batteries, external or internal, or from a mains power supply using a very simple, single transistor, series stabiliser, Q411. Amplified AGC is obtained from a single transistor, Q407, also fed from the collector of Q406. This is arranged to provide a DC signal which becomes progressively more positive as the IF signal strength decreases. The signal strength meter is also fed from this stage, but with a signal voltage which falls as the IF output diminishes.

RF, Mixer, and Input Double-Conversion Stages

A simplified circuit diagram for this section is shown in Fig. 2. As in the 2-3 MHz section of the receiver, a dual-gate MOSFET, Q101, is used as the RF stage. Four switched tuned circuits on the input to this provide an initial selection of the input signals, in the range 0.5-30 MHz. These are tuned by a single gang, 300pF, capacitor with adjustment for the minimum capacitance value and coil inductance being provided for each range.

Although it might appear somewhat surprising in a sophisticated receiver design to have only one RF tuned stage preceding the mixer, in view of the fact that the operation is based on the initial amplification of a one megahertz-plus wide slab of RF signals, too high a degree of aerial selectivity would be an embarrassment in operation. This is all too readily apparent on the 'medium wave' broadcast bands.

The first frequency changer, which is a double-balanced type, in the interests of the lowest practicable conversion noise, coupled with low cross-modulation characteristics, consists of a pair of matched junction FETs, Q102, Q103, fed directly from the RF stage, without any further tuning, through a nine-element Cauer filter, operative above 30 MHz, and having a very steep cut-off characteristic, which is of the order of 60dB/octave. Since the aerial selectivity is not very high at the high frequency end, this is essential to exclude unwanted signals from the 54.5-55.5 MHz first IF stages.

The output from the first mixer (Q102, Q103) is taken through a pair of double tuned IF transformers, T105, T106 and T107, T108, and a dual-gate MOSFET first IF amplifier, Q104, to a second frequency changer stage where the downward frequency conversion to 2-3 MHz takes place. As in the 2-3 MHz tuned amplifier, the circuit used here employs a junction FET with the 'local oscillator' signal injected into its source. The output signal from the drain of the FET is fed to the tuned receiver described in the first section of the circuit description.

The first IF is, as mentioned above, a broadly tuned stage, giving an approximately flat-topped response over the 54.5-55.5 MHz band. To assist in obtaining the desired overcoupled bandpass characteristics, the IF transformers T105-108 are individually screened and coupled by small external capacitors rather than by mutual inductance, as is more conventionally the case in double-tuned IF transformers for, say, 465 kHz IF use.

The Drift-Cancelling Oscillator System

I have put the description 'local oscillator', used above, in inverted commas because it is in respect of this circuit that the main difference between the Barlow-Wadley system and the ordinary superhet lies, so the local oscillator input to the second mixer is far from being a standard output from a conventional variable frequency oscillator.

The way this part of the circuit works can best be appreciated by going back to the beginning again. As mentioned above, the first RF stage is tuned to the incoming signal frequency and is taken through a low-pass filter to the first mixer (Q102, 103). Since the input frequency coverage is, nominally, 0.5-30 MHz and the first IF is centred on 55 MHz, the local oscillator frequency for the first mixer needs to cover the frequency range 55.5-85 MHz. This can be done conveniently, on a single sweep, using a 60pF variable capacitor, VC201, using a single transistor, Q201, and a single coil, T201, in a grounded-base Colpitts oscillator circuit. A simplified circuit is shown in Fig. 3.

To minimise loading on the oscillator circuit, a small secondary winding is used to pick off the oscillator output voltage to feed to the first mixer (Q102, 103). However, this is where the drift cancelling system begins, because the output from the first VFO is also taken to a double-balanced modulator IC, a *Texas* Instruments SN76514 (Q106), where it is mixed with the output from a crystal oscillator harmonic generator. The understanding of the operation of this is the key to the comprehension of the receiver system as a whole. Fortunately, it isn't too difficult.

The first part of this is a straightforward, 1 MHz crystal oscillator, built around a single transistor, Q301. This feeds a twin diode squarer circuit, D301, D302, which feeds the modulator IC through another steep-cut LC low-pass filter, L303-1 L303-4, which has a sharp cut-off above about 33 MHz. This generates a slab of harmonics from 2-32 MHz which are mixed with the output of the local oscillator to give an output, at pin 3 of the SN76514 IC, containing frequencies ranging from 23.5 to 117.5 MHz, depending on the actual tuned frequency of the VFO. (These are the sum and difference frequencies of the VFO frequency and the output of the harmonic generator). The actual frequency, among this lot, which is used as the 'local oscillator' input to the second mixer (Q105) is determined by a four-stage bandpass tuned RF amplifier, consisting of the coils T109-T116 and the transistors Q107, 108, 109.

Although only one frequency, nominally 52.5 MHz, is used, the bandwidth of this amplifier chain must not be too narrow or it will make the tuning of the first oscillator too critical, and make the sensitivity of the receiver too dependent on the absence of drift in this VFO. However, this is not a critical point. Something over 0.5 volts r.m.s. output is necessary from this amplifier chain for proper operation of the second mixer stage, Q105, and this is monitored by a simple two-stage DC amplifier, Q110, Q111, which extinguishes an LED when an adequate RF voltage is present at the input to the peak rectifier diode, D102. This is the LED on the front of the receiver alongside the 'MHz selector' tuning knob, which controls the VFO tuned frequency.

The operation of the system can now be seen. Suppose it is desired to receive a signal of 15 MHz frequency. The input tuned circuit, on band 'D', will be tuned to 15 MHz. The VFO will be tuned to about 70.5 MHz, though the precise frequency is not very critical, and the output of the first mixer will be about 55.5 MHz which will be amplified by the first IF stage and fed to the second mixer. Meanwhile, the output of the VFO has simultaneously been mixed with the 18th harmonic of the crystal oscillator (18 MHz) to give the oscillator input at 52.5 MHz for the second mixer. This provides a difference frequency output of 3 MHz to the final tuned receiver stage, which will be tuned at '0' on the 'kHz' scale operated by the main tuning knob.

If the VFO were to drift downwards in frequency to 70.4 MHz, the first IF frequency would become 55.4 MHz — and the output of the selective amplifier chain between the modulator IC and the second mixer would be 52.4 MHz, which is the point of the system. This means that the signal presented to the tuned stage of the receiver would remain at 3.00 MHz — *i.e.* no drift. Unfortunately, this technique does not compensate for drift in the tuned frequency of the 2-3 MHz section of the receiver, but this is less serious since at the two ends of the tuned band the dial can be corrected by finding a heterodyne whistle with one or other of the week stray harmonics of the 1 MHz internal crystal. Drift in this section can be a nuisance in receiving USB or LSB suppressed carrier signals, where even a drift of a few tens of Hz, in this or the BFO frequency, can be annoying.

One side effect of the upward and downward frequency conversion in the first and second mixer stages is that the tuning of

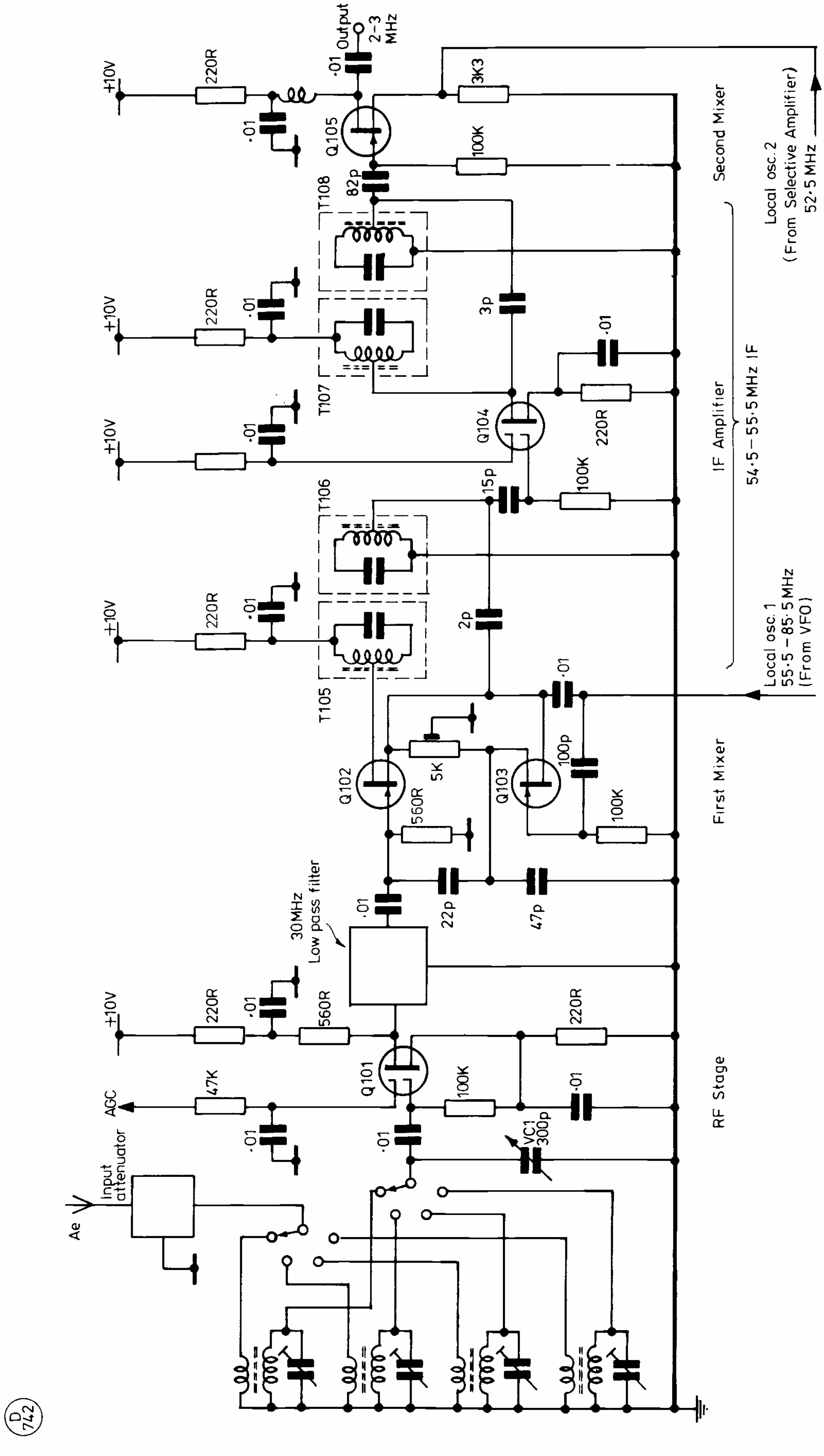


Fig. 2 RF MIXER AND FIRST IF STAGE OF THE F.R.G.7

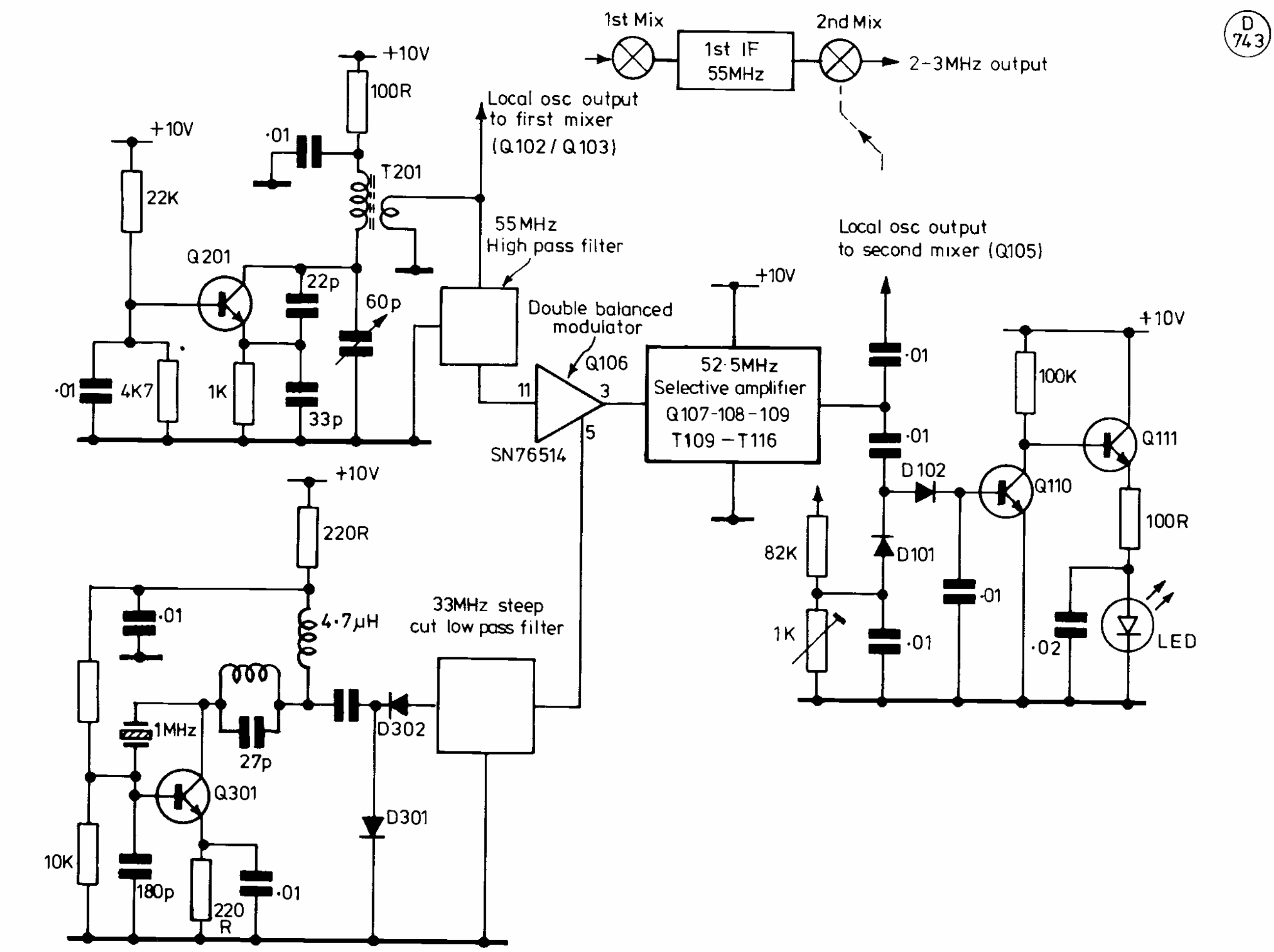


Fig. 3 THE "BARLOW-WADLEY" LOOP The drift cancelling local oscillator arrangement of the F.R.G.7

the tuned stages of the receiver appears to be 'backwards' way round, so that, taking the example given above, a 15 MHz + 0 kHz signal is tuned at 3 MHz, while a 15MHz + 999kHz signal is tuned at 2.001 MHz. This phenomenon is only of concern in the alignment of the receiver, where it must be borne in mind to avoid the wrong trimmers being tuned inadvertently, and in fitting a frequency counter to the receiver, where this must also be organised to read the wrong way round!

I have, I regret, seen a recommendation to retune the selective tuned stages which provide the second 'local oscillator' signal, so that these give an output of 57.5 MHz rather than 52.5 MHz, to simplify the organisation of a second stage frequency counter. The snag with this would be that an input frequency of 15 MHz would require the 13th (13 MHz) harmonic of the crystal. What would a 1 MHz input frequency need — 1 MHz? Apart from this, the drift cancelling system would still work quite well, but only at frequencies of 3 MHz and above!

Although the structure of the receiver appears to be quite complex, which would suggest that there could be problems in use, in practice it appears to work very reliably and well, with very few spurious signals due to unwanted harmonics of the crystal, or its sum and difference frequencies with the other VFO's in the circuit. Certainly, the very high first IF frequency eliminates entirely the pest of second channel interference, so common in earlier short wave receivers. Also, the well organised RF and first mixer circuit gives an input sensitivity which is very well maintained up to the maximum 29.9 MHz nominal limit of the tuning range. The only real shortcoming inherent in the circuit design is that there is very little real selectivity in the circuit up to the input of the 455 kHz third IF stage. This does allow quite a bit of scope for unwanted cross-modulation — not only between the wanted signal and powerful unwanted signals within the 1 MHz pass-band of the first IFs, but also, more insidiously, between the signal and the wideband noise within this passband. This means that although the ultimate sensitivity of the receiver, when correctly aligned, is probably of the order of 0.02 μV — in the sense that a signal this small can be detected — the usable sensitivity, at which the signal has an adequate signal to noise ratio, is less than one tenth of this. Nevertheless, although it does give scope for better receivers to show their merit, in practice it more than meets the requirements of anyone wishing to receive commercial broadcast signals anywhere within its frequency range.

Certainly, in my own case, with a vertical aerial of about 15 feet length, the general noise threshold of the receiver is mostly provided by the higher harmonics of 50 Hz radiated by the overhead high voltage power lines, some mile or two away, and at least 20dB of aerial attenuation is normally necessary for general short wave listening on the commercial bands.

Part II will describe the alignment procedure for the receiver.

CIRCUIT OPERATION AND ALIGNMENT OF THE FRG-7 RECEIVER, PART II

RECEIVER ALIGNMENT PROCEDURES

J. L. LINSLEY HOOD, MIEE, MIMC

IN THE first part of this article I tried to provide a 'conducted tour' through the electronic circuit of this receiver, partly as a means of providing a greater insight into its way of operation, so that the user could have a greater appreciation of its potential strengths and limitations, and partly as a necessary preamble to clarify those areas under consideration if the user wished to improve or restore the alignment of the tuned circuits in the instrument.

While some of the more simple adjustments can be done, without misgivings, without the benefit of the Yaesu owner's instruction manual, and with little more than one or two small screwdrivers by way of equipment, it is urged that any more comprehensive adjustments should not be attempted without a copy of the manual, a reasonable collection of small tools, a frequency counter which will cover the range up to 100 MHz, an adequate HF signal generator, with an output attenuator, and a high impedance (preferably electronic) voltmeter. With these, and a bit of patience, wonders can be done!

Since I can remember well what it was like not to have a good collection of instruments (which didn't, I recall, stop me from wanting to do those things which the subsequent possession of those instruments made a lot easier), I will start with the easy ones — with the caution that some of these would be worth leaving until later if one has better test equipment. I will indicate when this is the case.

RF Stage Alignment

The initial tuning of the receiver is a single tuned circuit on the input to the RF stage preceding the first mixer. This is the part controlled by the 'Band' switch and the 'Preselect' knob on the far left of the front panel of the unit. This should give a scale reading appropriate to the frequency to which the Rx is tuned, so that if one is on, say, 21 MHz, the 'Preselect' dial should indeed read this figure when the S-meter shows maximum signal. However, this is easy to arrange.

Looking at the upper half, with the case removed from the receiver, the RF section is on the PCB to the left of the mains transformer and behind the twin-gang 300 pF RF tuning capacitor. (Although only a single 300 pF is used, separate gangs are used for the MW and the three SW bands.) The adjustments required are to the coil trimmers T101-104 and the trimmer capacitors TC101-104. These numbers are marked on the PCB, and on the diagram on page 13 of the manual. In each case, the preferred adjustment is to the inductor, first, at the bottom end of the band, followed by the trimmer capacitor at the high frequency end. While a signal generator makes this task a little easier, it is far from being essential, since a suitable signal can almost always be found near the desired spot on the lower frequencies, and aerial noise will serve quite well on the higher ones (though here, do not rely on the ear to judge maximum, but use the voltmeter on an AC range across the LS terminals as a 'noise strength' meter).

While on this subject, I would recommend that an external, longer scale, instrument should be connected across the internal S-meter, where possible, since this makes accurate adjustments easier. However, the main moral is — don't judge by ear! This organ is very uncritical of small changes in loudness, and a series of nearly correct adjustments can rapidly add up to a very inferior final result.

The procedure is simple. On band 'A' find a suitable signal at or near 0.5 MHz, and adjust coil T101 until the S-meter shows maximum deflection when the input signal has been reduced on the generator, or by other means, so that the reading is at about half-scale. Too large a signal input will make the meter difficult to read, and will modify the receiver response unfavourably for this purpose. When this has been done, repeat the exercise at 1.6 MHz with adjustment to the capacitor TC101. (A trimmer screwdriver with a small, insulated, blade such as the *RS* 543-399 and 543-334 "Trimtool" is desirable here.) The same procedure is then carried out for the other input ranges, at 1.6-4 MHz, 4-11 MHz and 11-30 MHz. If one has perfectionist inclinations, each range can be checked over twice — by going back to the bottom end again after the top end has been tuned and then returning to the top.

Sadly, this exercise is likely only to be cosmetic, unless the tuning is so far out that signals at the extremes of the range could not be properly tuned on the input. However, it is nice to have things right.

The Main Tuning Scale

Only do this adjustment at this stage if you do not intend to check the operating frequency of the BFO. If you do, leave it to later.

Firstly, set the 'Fine' tuning knob to vertical, and anchor the sliding 'Dial Set' cursor so that it is in the middle of its travel with a piece of adhesive tape. Then with the 'MHz' scale set to 29, and the 'Preselect' range set to 'A' (to limit the amount of unwanted aerial signals present), tune the main scale to a reading of 1000; this will effectively tune the second, variable frequency, part of the receiver to 2 MHz. If the 'Mode' switch is now turned to the 'LSB' position, a whistle should be heard due to the receiver picking up a very small amount of one of the harmonics of the internal 1 MHz crystal. For most practical purposes, it is sufficient to adjust the third oscillator frequency (Q403) so that there is a zero beat, by adjustment of the ferrite core slug of T403. If the upper and lower VFO frequencies have been adjusted, a neater style of adjustment is such that the beat note for the LSB and USB switch positions is identical.

The main tuning is then set to '0' and the exercise repeated with TC403. This, of course, is to set the receiver tuned stage to 3 MHz.

The Main Oscillator "MHz" Scale

It will be recalled from the first part of this article that this part of the circuit a Colpitts oscillator covering the range 55.5-85 MHz, tuned by a single variable capacitor (this is actually two 30pF capacitors connected in parallel). Although a signal generator is helpful, it isn't absolutely essential for this adjustment, provided that the receiver is not too far in error. To proceed with this, find a signal as close as may be practicable to 3.5 MHz, and tune to this; adjust the slug in coil T201 gently (some delicacy in this is desirable, as well as a low-capacitance trimmer tool) until the 'lock' lamp extinguishes with the 'MHz' tuning scale at the middle position of the scale 'blob' marked '3'. Now look for another signal at around the 27.5 MHz mark, and tune to this. Then adjust the trimmer capacitor TC201 until the LED lamp labelled 'lock' extinguishes in the middle of the 'blob' labelled '27'. A little care is necessary here not to get a complete 1 MHz step out; however, one can count up from the bottom to make sure that the lamp extinguishes the right number of times.

Because of some small errors in the law of the capacitor, or the engraving of the 'MHz' dial, it will probably not prove possible to achieve the desirable result of the 'lock' lamp extinguishing in the middle position of every MHz calibration, but one can get near this. As in the case of the RF stage alignment, these adjustments are only 'cosmetic' and will not

The author's FRG-7 and home-built digital frequency meter.

do more than make the receiver tuning behave as intended. Nevertheless, they do help make using it more satisfying. For tangible performance benefits, the equipment listed above is very desirable, though the resourceful and competent may achieve much with limited facilities. I assume, though, that those wishing to proceed beyond this point will have access to necessary apparatus.

The BFO

This injects into the diode ring-modulator at the end of the 455 kHz 3rd IF chain, through an emitter follower buffer stage. The required operating frequencies are 457 kHz in the LSB position of the mode switch (set by adjustment to the coil slug T406) and 453 kHz in the USB position (set by trimmer capacitor TC404, which only comes into operation on this switch position). A frequency counter is desirable for this, connected to TP405.

The 3rd IF, 455 kHz

The procedure recommended by Yaesu makes the assumption that the 455 kHz mechanical filter FL-1 is correct, and proposes that one should merely tune to a signal generator set to 7.5 MHz, and then adjust the coils on the output of the 1st and 2nd 455 kHz IF stages (T404 and T405) for maximum S-meter reading. I prefer to dangle a short length of insulated wire connected to the signal generator output in proximity to the transistor Q402 (the 3rd mixer), with the signal generator tuned to 455 kHz, and rely on enough pick up or breakthrough. However, this isn't a very critical adjustment since only T404 is at all sharp in tuning; T405 is very damped, which makes it difficult to be sure of optimum adjustment.

The 2nd IF, 3-2 MHz. Variable (Tuned) Frequency

Some benefits can be gained from setting this correctly, but keep in mind the point that the tuning works 'backwards', so that the coils are adjusted apparently at the higher input frequency, and the trimmer capacitors at the lower. Having said that, it helps to adjust these a little way in from the end of the tuning range. The Yaesu recommendation is to tune to 7.1 MHz to adjust the trimmer capacitors TC401, TC402 and then to tune to 7.9 MHz to adjust the coils T401, T402. This adjustment is, inevitably, repetitive until the optimum setting is achieved, but should show some improvements in general receiver performance.

The 1st IF, 54.5-55.5 MHz Bandpass

The purpose of this stage is to amplify, uniformly, a slab of signals 1 MHz wide, plus a bit at either end. To achieve this, four separate, individually screened, coils are used with external coupling capacitors (2 and 3pF respectively) to achieve the desired over-coupled double-hump response. These tuned circuits are on the inputs to the IF amplifier (a dual gate MOSFET) and the second mixer (a junction FET).

If one has access to a wobbulator covering the 55 MHz band this task is relatively easy. (A simple DIY job is not too difficult to make: I use the one I described in the VCO article in *Wireless World*, September 1979, as an add-on mod to a cheap and cheerful commercially made signal generator). However, even in the absence of such a piece of kit, it is still straightforward, though more laborious. The procedure is to inject a signal in the desired frequency range into the first mixer (Q102-Q103), *via* test point TP103, with the receiver tuned to 20.5 MHz and the aerial removed, and measure the output from the stage, at the end of the strip, at TP104 using a good 'scope.

A method which is slightly less demanding of equipment is simply to swing the signal generator frequency up and down over this frequency range and measure the output — either by tuning in on the main tuning knob and using the S-meter, or by means of the simple gadget shown in Fig. 1, which allows a high impedance voltmeter to act as a crude RF meter; a sensitive meter helps. However, keep the RF leads short, and let the DC leads be the longer ones. The aim in tuning these coils is to get the flattest response over the 54.5-55.5 MHz band, compatible with sensitivity. Some method in the adjustment procedure is essential, and I would commend the tuning of T106 and T105 to a maximum at 54.8 MHz, and T107 and T108 to a maximum at 55.2 MHz.

As a final check on the extent to which one has achieved the desirable end of a uniform sensitivity of the receiver across the whole 1 MHz band covered by the kilohertz tuning scale, one can tune to the top band of the Rx (29-30 MHz) and check that the aerial noise is reasonably constant across this swing. However, prepare to be a bit disappointed in this. Nevertheless, some useful improvement in Rx sensitivity will probably be made by setting these coils to the compromise optimum.

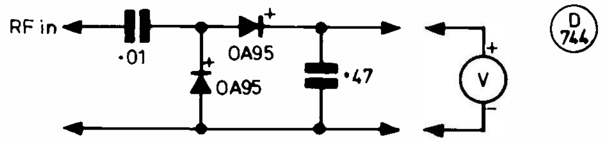


Fig. 1 Simple circuit to allow monitoring of RF signal levels using sensitive high impedance DC voltmeter

The 52.5 MHz Selective Amplifier

I have left to the last the adjustment which is likely to bring about the biggest improvement in receiver sensitivity of all these tuning adjustments, which is the alignment of the 8 coils in the three-stage selective amplifier which feeds the second mixer oscillator input.

This mixer, Q105, is an N-channel junction FET with the signal input from the 55 MHz IF stage applied to its gate and a local oscillator RF signal applied to its source. For good conversion efficiency, at least 0.5v. r.m.s. is needed as this input, and the task of the selective amplifier is to extract a signal of this magnitude, at around the 52.5 MHz frequency mark, from the miscellaneous RF rubbish generated at the pin 3 output of the *Texas* SN76514N double-balanced modulator IC. To recap. from *Part I* of the article, the input to this IC is provided by the first oscillator, and also the output from the 2-33 MHz harmonic generator driven by the internal 1 MHz crystal.

To accomplish the alignment of these tuned stages, it is necessary to remove the LO input, either by disconnecting or by earthing it at TP101; a 52.5 MHz input can then be fed from the signal generator into the input stage of the selective amplifier at TP107. Ideally, the output as measured with the gadget shown in Fig. 1 connected to TP109, at the output of the selective amplifier, should be constant over a bandwidth of some 100 kHz centred on 52.5 MHz, and adjustments to coils T109-T116 — situated in a double row on the right-hand side of the RF unit PCB — should be made until this is achieved as well as possible.

The reason for the attempt to attain a flat-topped frequency response from this amplifier chain, is that too sharp a tuned response would make the setting of the 'MHz' knob too critical, and would emphasise changes in sensitivity arising from small drifts in the local oscillator frequency, which is undesirable. There is, I think, little cause for worry on this score, since a 52.5 MHz amplifier cannot readily achieve a selectivity much better than this unless some incipient instability is present which would indicate a faulty component.

For this reason, when the centre frequency of the amplifier has been established correctly, the local oscillator input can be restored, and the RF signal voltage produced at TP109 can be monitored as the "MHz" knob is adjusted — with a little delicate tweaking of the coil adjustments to optimise the ouput. If wished, at this stage, the setting of the DC threshold of the 'lock' level monitor can be adjusted, by VR102, so that the extinction of the LED is reasonably precise, without being too fussy. In my experience, the influence of the oscillator signal input to the second mixer, and derived from this chain, is so great — both in its effect on the receiver sensitivity and upon the elimination of spurious signals 1 MHz remote from the chosen tuned frequency — that the whole Rx performance can be noticeably improved.

Sundries

The only other adjustment which it would seem worthwhile to make, while the receiver is out of its case, is the adjustment to the balance of the mixer. This is done by disconnecting the aerial, setting the 'MHz' knob to '0', and tuning to the internal spurious signal at 910 kHz; VR101, at the front of the RF unit, can then be adjusted to reduce the magnitude of this on the S-meter. It is a fairly flat adjustment, with a minimum of about 5-6 on the 'S' scale. The manual also refers to TC105, but this control no longer exists in the circuit.

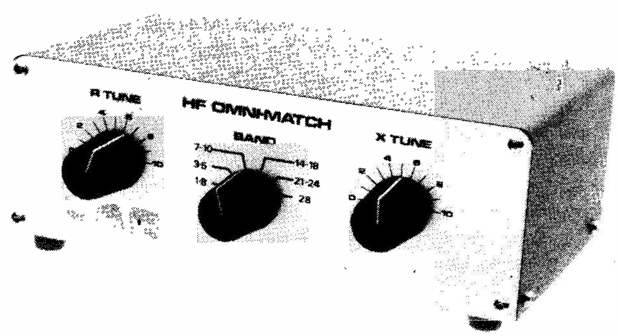
For a receiver which is as sensitive as the FRG-7, when aligned as the designer had intended, the adjacent channel selectivity is only marginally adequate for use on the SW broadcast bands, where very strong signals can exist in close proximity to weaker ones of interest, and where the agreed 8 kHz separation between stations is frequently ignored. In these circumstances, particularly if reception conditions are good, some improvement in the 3rd IF selectivity is a good idea, and several DIY mods. have been proposed to this end. In my own case, I made a direct replacement of the LFC-6 455 kHz filter with a *Murata* CFG4551, which has given as high a selectivity as would be practicable for general purpose broadcast listening.

However, every mod. brings problems, and the snag in this case is that it becomes very difficult to be absolutely certain of the frequency to which one is tuned, since the selectivity is now several times better than the allowed lateral movement of the tuning cursor, or even the precision of calibration of the kilohertz dial, so a digital frequency display then becomes the next requirement. At this stage it is sensible to ask whether it would not have been better to have bought a more expensive model incorporating a digital frequency meter in the first place!

For those, like me, to which this piece of wisdom came a little late in the day, there are add-on frequency meters, both as commercial units and as DIY jobs, of which one that comes to mind, at once, is that in *Short Wave Magazine*, Jan-Feb 1980. My own, very simple, frequency meter — for which no magic whatever is claimed — solved those operating problems which arose when I improved the selectivity of the design, and is shown on top of the FRG-7 in the photograph.

In conclusion, I can only say that the FRG-7 is a good receiver, of more than adequate sensitivity, and free from many of the shortcomings so often found in such receivers. It is clearly very popular as a general purpose instrument, and I think deservedly so.

concluded



The new *LAR Modules* HF Omni-match which will tame a VSWR as high as 5:1. It is available from them at their 60 Green Road, Leeds LS6 4JP address, price £71.00 including VAT and post/packing.

ment be necessary the cable to be trimmed is L7. If it is not possible to balance them it may be necessary to add a short length of 52-ohm coax between the end of L13 and the connection to Sw1d.

Repeat the same procedure for 10 metres, adjusting the length of L8, or adding a short length of 52-ohm coax between the end of L14 and Sw1D.

It is not so important to check the "out of phase" or cardiod positions; if these are not exactly 180° or 90° it simply means that the directional pattern of the two verticals will be slightly moved to one side or the other—however, with patience it is possible to get these to perfect accuracy by the method previously described, but noting the frequency difference between the "in phase" and "out of phase," and adjusting the appropriate switch connections accordingly.

Results

The foregoing may seem somewhat complicated, but the fact is that no antenna system will work at maximum attainable efficiency unless quite a lot of time is spent on detailed measurements and adjustments. If the system is correctly adjusted and the two ground planes are reasonably in the clear, the lobe patterns and extremely low-angle radiation prove most effective for DX workings. The writer's system is laid out to give the two cardiod patterns on 20 metres towards VK and ZL for the long and short paths. Signal reports have been most gratifying, and the ability to cut down (and even eliminate) QRM at the turn of a switch certainly makes the effort seem well worth while.

SWITCHED SELECTIVITY FILTER FOR THE FRG-7 USING TOKO MFL455 AND MFH41T FILTERS

PLUS ADDITIONAL IF AMPLIFIER STAGE

R. F. MILLINGTON

THE circuit devised, and described in the July 1978 issue of *Short Wave Magazine*, by R. Barker was just the circuit I was looking for to get the best out of my FRG-7, but no way could I afford—or indeed would the XYL authorise—the £50 outlay for the Collins filter. Not having much experience in working out component values for changes in impedances etc., I nevertheless decided to take a chance and send for the Toko SSB filter, mentioned by Mr. Barker, and have a go. Also, unwilling to apply a hot iron to a PCB in a confined space for any length of time, I decided not to remove the original filter but to bypass it, and use the Toko MFH41T mechanical filter, with a quoted passband of 4 KHz.

The circuit, Fig. 1, is the same as that given by Mr. Barker, except for the components forming the input and output impedances. R1 and R2 give the required input impedance for the SSB filter, 5K, and R11 in conjunction with the impedance of Q405 provide about 1K. R4,R5, R12,C5 and C8 provide the required impedances for the AM filter.

Originally the filter board was made and tried out, with the hoped for improvement in selectivity—though with the reduction in signal as Mr. Barker described; whether or not the losses were worse with the Toko filter I do not know, but although readable with the phones on, loudspeaker volume was very poor, even with the volume control fully on.

I found a circuit (Fig. 2) for a crystal-filter/IF amp, and adapted the IF amp circuit. Although not AGC controlled it works extremely well for the small number of components involved, and for the extra cost it is well worth while; Fig. 4 shows layout. The input impedance of the IF amp, although more than that required by the filter, did not seem to detract from the efficiency of the filter, so R11 and R12 were left in circuit and not changed.

It was thought advantageous to have the filters switchable independently of the 'Mode' control, and the spare contacts on the 'Lights On/Off' switch was used, so as not to drill into the metal work. It was wired so that the AM filter was in circuit with the lights on. There is one problem with this method of switching when the two filters used are on different frequencies: with the BFO correctly tuned to give 1.5 KHz output with the SSB filter in circuit (*i.e.* with an IF of 453.5 KHz) and BFO for USB on 452 KHz, and the AM filter on 455 KHz switched in, the resultant output will be 3 KHz. It is of course the same on LSB, except that the resultant AM filter output is now zero beat. When reading Morse this can be an advantage; but whether CW or SSB, if tuned-in correctly using the AM filter, then no retuning is necessary when switching to the SSB filter.

T1 and T2 are part of the MFL455 filter, and come with a small printed circuit board. This was used and mounted on the *Veroboard*, Fig. 3, using stiff pieces of wire (resistor lead off-cuts). T3 comes with the MFH41T filter

Table of Values

Fig. 1

R1, R4	= 3K	F1	= MFL455 mech. filter, supplied with matching transformers T1 and T2.
R2, R5	= 2K	F2	= MFH41T mech. filter, supplied with matching transformer T3.
R3, R10	= 2.2K	D1 to D6	= 1N4148
R6, R8	= 47K	TR1, TR2	= BC109
R7, R9, R11	= 680R, 0.5w.		
R12	= 470R		
C1, C3, C4, C6, C7, C9, C10, C12, C13, C14	= 0.1 μF		
C2, C11	= 4.7 pF s/m		
C5	= 500 pF, s/m		
C8	= 200 pF s/m		
L1 to L8	= Type 8RB 10mH fixed		

Note: Components L1 to L8, F1 and F2 are available from *Ambit International.*

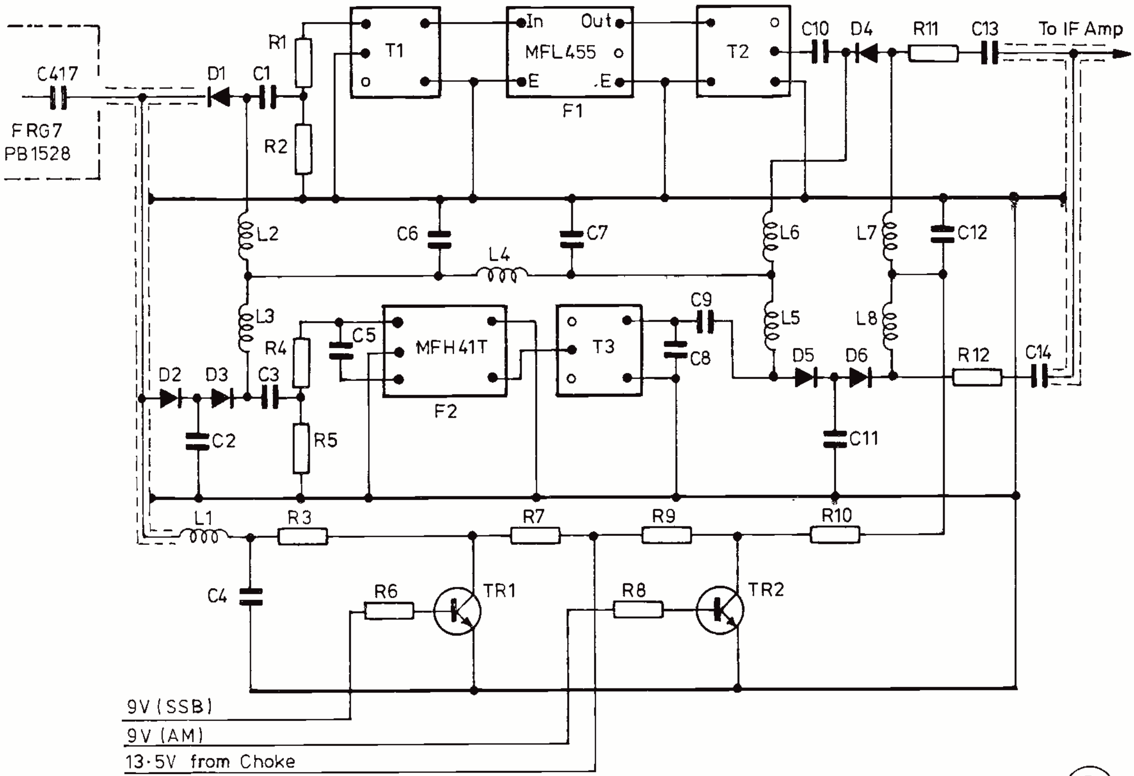


Fig. 1 SWITCHED SELECTIVITY FILTER

but with no PCB, so care has to be taken in enlarging the *Veroboard* holes and fitting the pins in without force. If making up the filter *and* the IF amp, then use a piece of board approximately 7" long and 3" high; only 26 holes on this side were used as the remainder were used for mounting the board. A bracket was constructed with

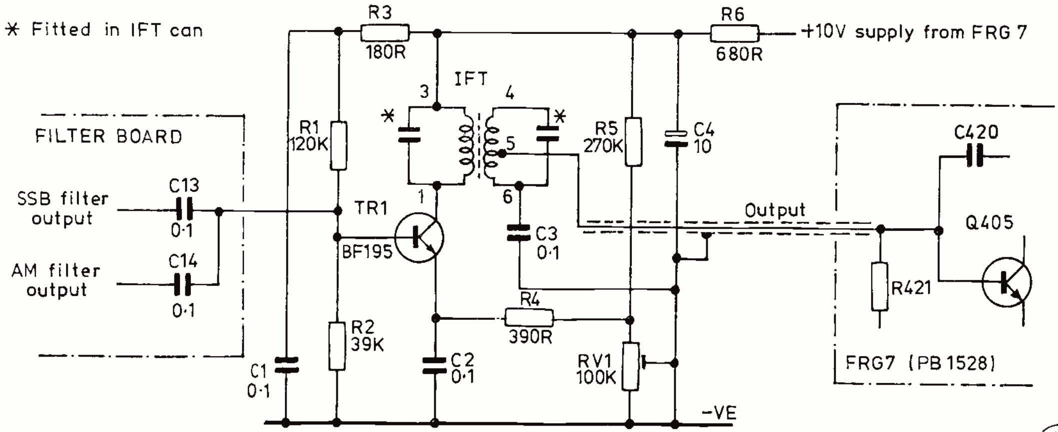
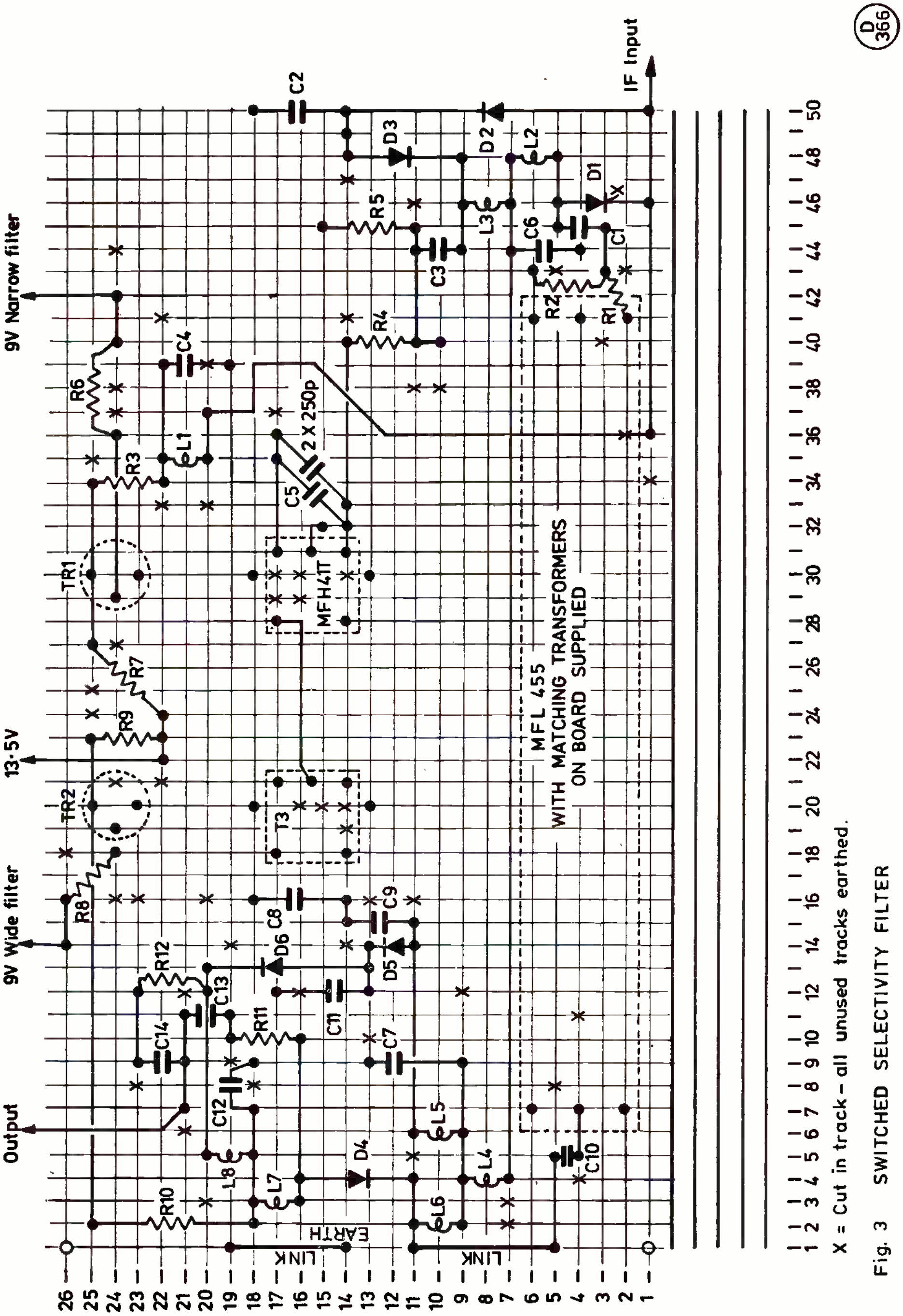


Fig. 2 ADDITIONAL IF AMPLIFIER

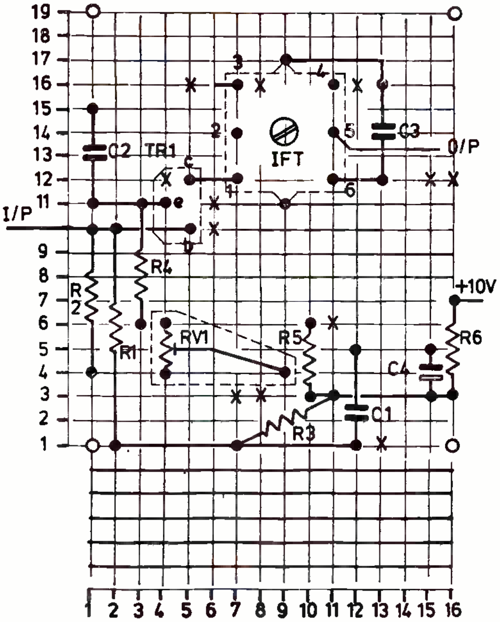
D 365

The IFT used (a Denco IFT18/465) was recovered from the junk-box and is in no way critical: the circuit should work with any coupling coil as long as it can be turned to the IF frequency. Indeed a low-value resistor can be tuned to the IF frevuency. Indeed a low-value resistor can be substituted for the IFT, and the output taken via a 0.1 μF capacitor from the collector's junction. C1, C2 and C3 are ceramic at 30v. working; C4 is electrolytic at 25v. All resistors are ¼ watt.



X = Cut in track - all unused tracks earthed.

Fig. 3 SWITCHED SELECTIVITY FILTER



X = cut in track — all unused track is earthed.

Fig. 4 ADDITIONAL IF AMPLIFIER

D 367

with two feet bent at right-angles with centre holes, made so that the feet fitted over the fixing holes of the IF/AF PCB of the FRG-7, and so that it went between the inner end of the battery pack and that PCB. The *Veroboard* is then bolted to the bracket so that the SSB filter just clears the AF output IC and heat sink on this PCB. In this position the battery pack can still be used and no alteration has been made to the original set. No instability was noted either.

In order to keep the original filter in its place, the end of C417 at its junction with the filter was lifted (Fig. 5) and the inner of screened lead soldered directly to it, and the lead taken to the input of the switched filter. There is a small length of track leading from the output of the original filter to the junction of Q405, R421, and C420: this is cut with a sharp knife, making sure there is no bridge. The output from either the filter or the additional IF amp is taken to the R421/C420 junction *via* another length of screened lead. Should it be needed to return the set to its original condition, it is an easy matter to unsolder the screened leads, solder a bit of wire across the cut track, and reseat the end of C417.

As in the original circuit, the switching transistors get their voltage from the output side of the smoothing choke. Identify the pole of the 'Mode' switch which carried the 9v. BFO supply, and solder a length of wire from that point to the centre of the three connections on the unused side of the 'Lights' switch. Then connect a wire from the base of each switching transistor, as in the original circuit, one each to the remaining unused connections. The IF amp supply was taken from the set's 10v. stabilised supply—a convenient point being the input to the 'Lights' switch, as then all three wires can be bound together to make things tidy.

Setting Up

Follow the procedure described in Mr. Barker's article to receive, in effect, the receiver's 1 MHz oscillator. Adjust RV1 for maximum gain, then screw in the core on the output side of the *Denco* IFT until the signal is heard. Repeat the same procedure with the other core, adjusting the IF gain control, RV1, for best volume. Once this stage is aligned, adopt the procedure as detailed by Mr. Barker, remembering that in addition the cores of the filter's matching transformers will also need peaking up.

The IF gain control RV1 is adjusted to give enough amplification without overloading the receiver's IF strip and cause distortion, or gain which cannot be turned down by way of either the AF volume control or the *Ae* attenuator. Indeed, if the control was brought to the front panel it would be a useful asset, but I concentrated on being able to return the FGR-7 to its original state.

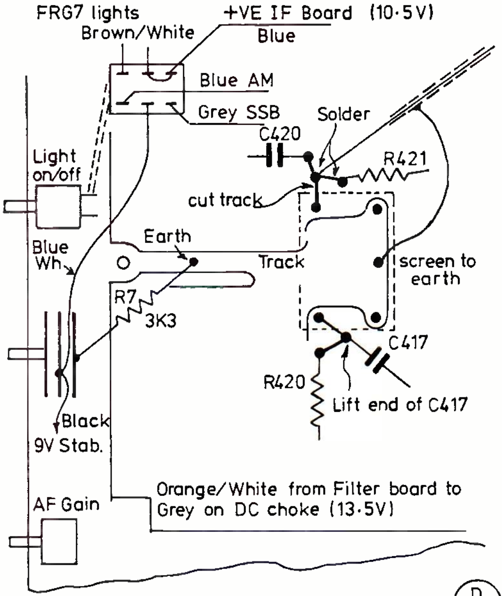


Fig. 5 UNDERSIDE OF IF-AF BOARD PB 1528

D 368

In conclusion, the circuit works very well, and the frustration factor of listening on 80 metres in the evenings has been greatly reduced, and the expense—in total not more than £20—has been well rewarded with far more enjoyable short wave listening.

My thanks to Mr. Barker for going to the trouble of publishing his circuit.

Reference:

"General Coverage Receiver", by F.G. Rayer, G30GR, *Practical Wireless* March 1976 (for additional IF stage and crystal filter).