

In your work -shop



PREVENTING A.M. IMAGE INTERFERENCE

Dick snapped into place the plastic back of the neat little medium and long wave radio and then switched it on. He selected medium waves and tuned it over the band. Radios 1, 2 and 3 turned up at their allotted points on the tuning scale, although Radio 1 and Radio 3 were marred by an irritating background whistle which changed in pitch as he tuned through the signals. He then checked the long wave band, to find that Radio 4 came in at reasonable strength. Cheerfully, he switched off the set and proceeded to take it over to the "Repaired" rack.

"Hey!"

Puzzled, Dick stopped in mid-stride.

"I said, hey!"

Dick located the sound as coming from Smithy's bench on the other side of the Workshop. Smithy had his back towards his assistant and appeared to be completely engrossed in a colour television chassis which lay before him on his bench.

Dick frowned.

"Did you say anything, Smithy?"

"Of course I said something," replied Smithy without looking round. "Am I to understand that you look upon the radio I've just been hearing as being fully serviceable?"

"Blimey, it must be," replied a confused Dick. "All that was wrong with it was that one of the leads from the medium wave coil on the ferrite rod-aerial had come adrift from the printed board. The aerial is

positioned close to the board and the leads from the coil consist of the thin coil wire itself. I should imagine that the set had been given a bump which had caused the wire to break. At any rate I simply soldered the wire back to the board, checked out the set and found it was working all right again."

QUICK REPAIR

"It sounded pretty horrible to me," commented Smithy. "Even over here I could hear what seemed to be quite strong image frequency whistles on two of the stations you tuned in. Bring it over here and let's take a butcher's at it."

Smithy pushed the television chassis to one side of his bench and accepted the radio which Dick handed him. He set it to medium waves again and checked its performance. The whistles were still very noticeable.

"Just a few whistles," commented Dick. "So what?"

"It's daytime now," stated Smithy, "and the medium wave band is pretty quiet. If you get image frequency whistles during daytime conditions the aerial tuned circuit of this radio must be quite some way off trim. At evening and night-time, when the medium wave band is absolutely chock-full with signals, you'd probably get whistles on nearly every signal you tune in."

"Why are you so sure that these whistles are image frequency ones, anyway?"

"Well," confessed Smithy, "I'm not a hundred per cent certain. But everything points to it. One of the major problems of medium wave reception with a simple superhet of the type we've got here is to avoid image frequency whistles, and this can only be done successfully by ensuring that the aerial tuned circuit gives maximum selectivity at the wanted signal frequency. You have yourself said that this radio has probably had a bump which caused a wire from the ferrite aerial medium wave coil to come adrift from the printed board. Following from this, and taking in the presence of those whistles, it seems quite probable also that said bump caused the medium wave aerial coil to be dislodged from its proper position on the ferrite aerial rod."

"Blow me," exclaimed Dick. "I never thought of that."

Smithy opened the back of the receiver and placed an experimental finger on the medium wave ferrite aerial coil.

"Hmm," he commented, "it's not all that tightly secured on the rod."

He tuned to the low frequency end of the medium wave band and found a station, with the tuning capacitor vanes nearly fully enmeshed, which was only just audible. He slowly pushed the medium wave coil along the rod, whereupon signal strength increased considerably. He soon found a point for the coil on the rod which corresponded to maximum signal strength. (Fig. 1).

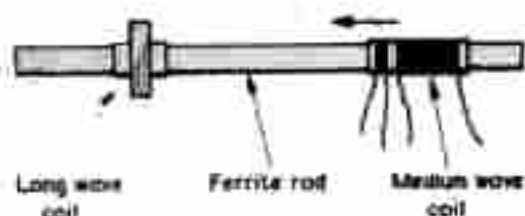


Fig. 1. Smithy brought the receiver serviced by Dick into more accurate alignment by sliding the medium wave coil along the ferrite aerial rod

"That's more like it," he said, "let's see how the set performs now."

He tuned across the medium wave band. The set was noticeably more lively and the whistles on the BBC1 and BBC3 signals had magically disappeared.

Dick was supremely impressed by this display of electronic legerdemain on the part of Smithy.

"Gosh Smithy, you're a genius!"

"Nonsense," retorted Smithy, "just a bit of elementary servicing, that's all."

"But why did moving that ferrite rod aerial coil clear those whistles?"

"Because," said Smithy patiently, "it made the aerial input tuned circuit peak more accurately at the required signal frequencies. Now look, as I've already said, this little set is a simple superhet, and it has an intermediate frequency which will be in the range of 455 to 475kHz or so. Let's say, for the sake of argument, that the i.f. is 460kHz. Right?"

"Right!"

"On medium waves," continued Smithy, "the signal coverage will be of the order of 550kHz at the low frequency end to 1,500kHz at the high frequency end. 550kHz is, rough check, the same as about 540 metres, and 1,500kHz is exactly the same as 200 metres. So we set up an aerial tuned circuit and an oscillator tuned circuit which are both tuned by a 2-gang capacitor. These are normally coupled, in a transistor radio, to a single transistor mixer-oscillator, and the tuned circuits are aligned so that the oscillator always runs at the intermediate frequency of 460kHz higher than the frequency to which the aerial circuit is tuned." (Fig. 2).

"I know all about that," protested Dick impatiently, "it's elementary superhet theory. The oscillator frequency beats with the incoming signal in the oscillator-mixer to produce sum and difference frequencies. It's the difference frequency we're interested in here and that goes into the 460kHz in-

intermediate frequency amplifier."

"Which," said Smithy, "provides most of the gain and most of the selectivity in the receiver. Right?"

"Right!"

"Good. Now having got that settled, the next thing we have to realise is that it is the oscillator frequency which chooses the serial signal which is going to go into the 460kHz i.f. amplifier. If we set the oscillator to run at, say, 1,460kHz then the signal which the oscillator selects to enter the i.f. amplifier will be one at 1,000kHz. Changing the oscillator frequency has the same effect as operating the tuning control of the receiver, because you're then selecting the signals which are going to be allowed to go into the highly selective i.f. amplifier. And we now come to a snag."

"Do you mean the image frequency business?"

"I do. If the oscillator is running at 1,460kHz, it will let in a 1,000kHz signal all right because there's a 460kHz difference between them. But if there happens to be another signal at 1,920kHz the oscillator will let that one in too because, once again, there is a 460kHz frequency difference between the two. The 1,920kHz signal is called the 'image' signal. It's also called a 'second channel' signal and it always appears at the frequency which is on the opposite side of the oscillator frequency to the desired signal, and which is spaced away from the oscillator frequency by the intermediate frequency. In a.m. medium and long wave radios the oscillator frequency is higher than the required signal frequency, and so the image signal appears above it."

"I suppose," said Dick, "that it's

the job of the signal frequency tuned circuit to stop the image signal getting through to the mixer."

"That's right," confirmed Smithy. "In high performance receivers you will have several tuned circuits resonant at signal frequency to stop the image signal, but in simple medium and long wave radios you have to rely on just a single tuned circuit to do the job. Fortunately, the coil in the tuned circuit is the one in the ferrite rod aerial and, because of the ferrite rod, it has a very high Q. In practice it doesn't actually prevent an image signal from getting through to the mixer, because with only a single tuned circuit a strong image signal can still manage to force its way past. Instead, the ferrite rod aerial tuned circuit boosts the desired signal so that its amplitude is much greater than that of the image signal."

"Hey, hold on a bit — you're getting away from me now!"

"Think about it," said Smithy. "Let's go back to our example in which the oscillation is running at 1,460kHz. Now, if the receiver has been aligned correctly the aerial tuned circuit will then be resonant at 1,000kHz. Suppose that, due to the receiver having had a bump, the medium wave ferrite aerial coil has become displaced on its rod, so that the signal tuned circuit resonant frequency has changed to 900kHz."

Dick frowned.

"Come off it Smithy, there's no need to rub it in."

"The response curve of the signal frequency tuned circuit," went on Smithy sternly, ignoring his assistant, "will now have a very high peak at 900kHz, but the skirts of the response will extend well up to the second channel frequency of

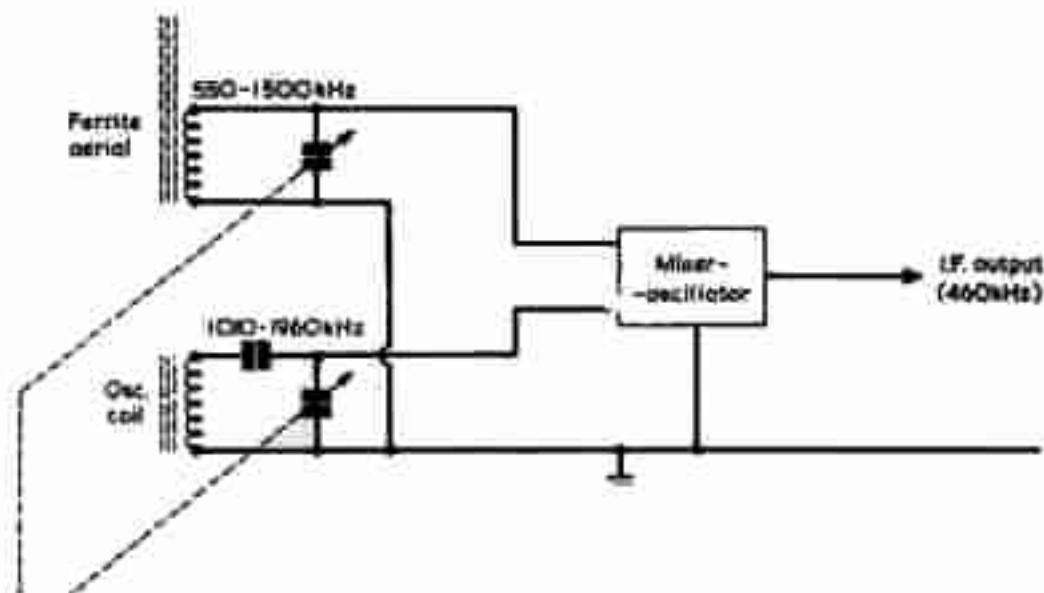


Fig. 2. On medium waves the signal frequency and oscillator tuned circuits are coupled to the mixer-oscillator. Both are tuned by a 2-gang capacitor, with the oscillator running 460kHz higher than signal frequency

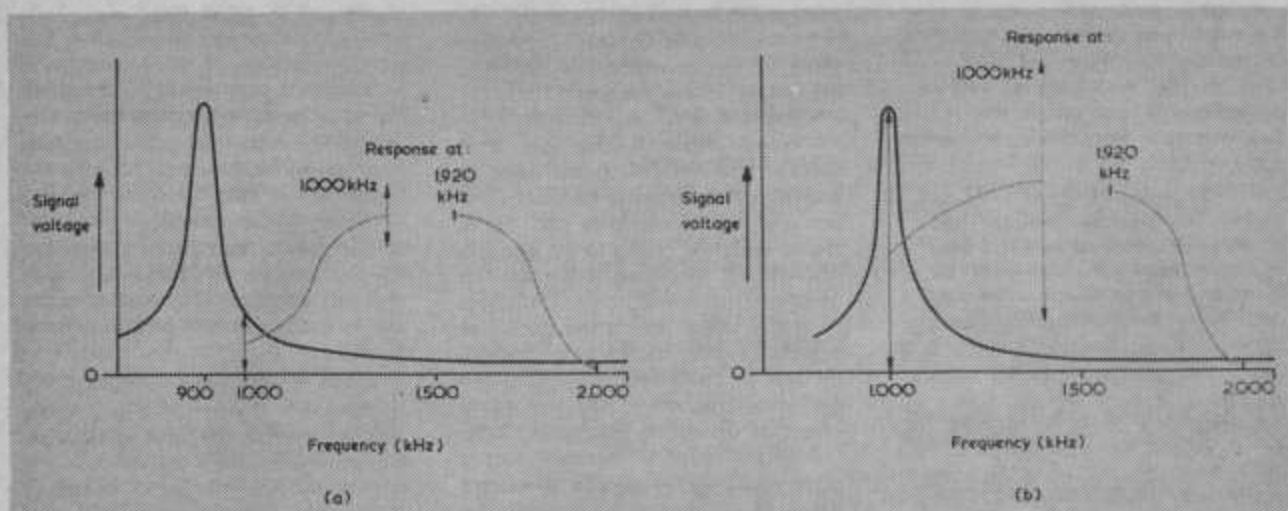


Fig. 3(a). A single ferrite aerial tuned circuit cannot completely eradicate image signals. The response curve shown here is for an aerial circuit incorrectly tuned to 900kHz when the desired input frequency is 1,000kHz. The response at 1,000kHz is not very much greater than the response at the image frequency of 1,920kHz

(b). When the aerial tuned circuit is correctly aligned to 1,000kHz, the response at this frequency is very much greater than that at the image frequency

1,920kHz. And so an image signal at that frequency will get through. As also, of course, will the desired 1,000kHz signal but, due to the detuning, its amplitude won't be very much greater than the amplitude of the image signal. Do you get the picture?" (Fig. 3(a).)

"Yes," replied Dick. "I think I can see what you're driving at."

"Well," said Smithy, "if we now readjust the aerial signal tuned circuit so that it resonates properly at 1,000kHz, we won't make any very noticeable difference to the amplitude of the second channel signal. But we will very greatly increase the amplitude of the required 1,000kHz signal so that, even though the second channel signal is still present, its amplitude will be so small relative to that of the required signal that it will in most instances have no audible effect in the receiver at all." (Fig. 3(b).)

TRIMMING CIRCUITS

"Stap me," said Dick slowly. "I've never looked upon the signal frequency tuned circuit of a medium and long wave superhet like that before. To get rid of image frequency whistles, then, you have to ensure that it's giving maximum boost to the desired signal so that any unwanted image signal fades into insignificance when compared with it."

"That's the idea," agreed Smithy. "You probably won't be able to get rid of *all* the second channel whistles on the medium wave band of a simple a.m. superhet receiver by careful alignment of the signal

frequency tuned circuit. But you will certainly get rid of most of them."

"What about long waves?"
"The same situation applies," stated Smithy, "but due to the frequencies involved the problem is not quite so acute. Say you want to pick up Radio 4 on 1,500 metres, or 200kHz. With an i.f. of 460kHz the image pops up at 200 plus 920, or 1,120kHz. This is relatively further removed in terms of frequency ratio from the desired signal frequency than occurs with medium wave images and so the difficulties are not so great. With the less expensive sets you often find that more attention is paid on medium waves to ensuring that the signal resonant frequency is accurately peaked at all settings of the tuning control than is paid on long waves. With poor designs you may even find that, if the long wave signal resonant frequency is correct at the Radio 4 frequency of 200kHz, this is considered good enough."

"Why," asked Dick, "do the image signals give these whistles? Why don't you actually hear the audio modulation which is present on the image signal?"

"You would do," replied Smithy, "if its amplitude were extremely strong. But the most audible effect is given by the image carrier, after conversion in frequency at the mixer, beating with the i.f. carrier of the required signal. The whistle changes in frequency as you vary the receiver tuning, by the way, because of the different frequencies at the output of the mixer. If oscillation frequency rises, for instance, the image carrier

intermediate frequency decreases whilst the required signal intermediate frequency increases."

Dick pondered on this for a moment.

"What did you mean just now," he queried, "when you said that medium and long wave sets usually have greater attention paid to correct signal frequency peaking on medium waves than occurs on long waves?"

MIXER CIRCUIT

Smithy leaned forward and picked up a sheaf of papers at the rear of his bench. He thumbed through these and gave a grunt of satisfaction as he located a service sheet on which was printed a receiver circuit diagram. He showed this to Dick, pointing to the mixer-oscillator section. (Fig. 4.)

"This," he commented, "is representative of what you get in a medium and long wave receiver when the circuitry is really cut to the bone."

"The wave-change switching certainly seems to be very basic," said Dick. "All it needs is a 2-pole 2-way switch."

"Exactly," confirmed Smithy. "Now let's see what happens when that switch is set to medium waves. The left-hand section of the switch takes the lower end of the medium wave ferrite rod coupling coil down to chassis via the 0.47 μ F capacitor, C1. That capacitor is virtually a dead short at r.f., and it also allows the mixer-oscillator transistor to receive d.c. base bias by way of R1 and R2. Right?"

"Right!" said Dick smartly. "And the right-hand section of the switch shorts out the long wave tuned winding on the ferrite aerial rod. So, everything is set up in the aerial department for medium wave reception."

"Quite so," said Smithy. "The prime requirement which has next to be met is to ensure that the ferrite aerial signal tuned circuit is always resonant at a frequency which is lower by the i.f. than the oscillator frequency at all settings of the 2-gang tuning capacitor, VC1(a) and (b). This is known, of course as 'tracking'. The aerial winding is tuned directly by VC1(a) and the trimmer TC2. The oscillator tuned winding has the padding capacitor, C4, between it and VC1(b). Another trimmer, TC4, is connected across VC1(b). The oscillator circuit is pretty straightforward, with positive feedback being given from the transistor collector back to its emitter."

"Does the padding capacitor cater for the fact that the oscillator tuning range is lower than the signal frequency tuning range?"

"It does. If we had a medium wave coverage of 550 to 1,500kHz, the oscillator range, with a 480kHz i.f., would be 1,010kHz to 1,960kHz. There is a lower ratio between maximum and minimum frequency, and so the oscillator tuned winding requires less tuning capacitance. The tuning capacitance

is reduced by putting C4 in series with VC1(b). Now, the medium wave aerial and oscillator circuits can be aligned very accurately to give almost perfect tracking over the whole range by adjusting TC2 and TC4 at the high frequency end of the band, and the inductance of the medium wave aerial coil and the inductance of the oscillator tuned winding at the low frequency end. You vary the aerial coil inductance by sliding the aerial coil along the ferrite rod and you vary the oscillator inductance by adjusting the core in the oscillator coil. Let's next move the switch to the long wave position."

"Righty-ho! Well, the switch section on the left connects C1 to the top end of the medium wave ferrite aerial coil via trimmer TC1. And the right-hand switch section takes the short off the long wave tuned winding."

"With the result," broke in Smithy, "that both tuned windings on the ferrite rod are in series for long wave reception as are both the coupling windings. The lower end of the coupling windings now effectively couples to chassis via R1 and R2. These resistors will offer some attenuation at long waves, which can be taken up by having a few more turns on the long wave coupling coil. The most important thing to notice takes place in the oscillator circuit. What happens here on long

waves is that there is no change in tuning inductance at all. Instead, the right hand switch section simply puts C3 and the trimmer TC3 across VC1(b). These capacitors bring the oscillator frequency down to the range required for long wave tuned circuits, by means of TC1 and TC3, and you *can* adjust the inductance of the long wave aerial coil by sliding it along the ferrite rod. But you *cannot* adjust the inductance of the long wave oscillator tuned winding."

"Why not?"

"Because if you do you'll mess up the alignment on medium waves. You can only align the receiver by first lining up the medium wave range and *then* going to the long wave band. If the receiver is a good design, the result of the medium wave alignment will be such that you can get good tracking on long waves with the limited long wave adjustments which are available to you. Ideally, you should align the medium and long wave bands exactly as detailed in the receiver service manual. With the better class of receiver there will be precise frequency indications at the high and low frequency ends of the tuning scale to enable you to get the medium wave alignment spot-on. The situation for long waves will then be that which the receiver designer has decided will give optimum tracking on that band."

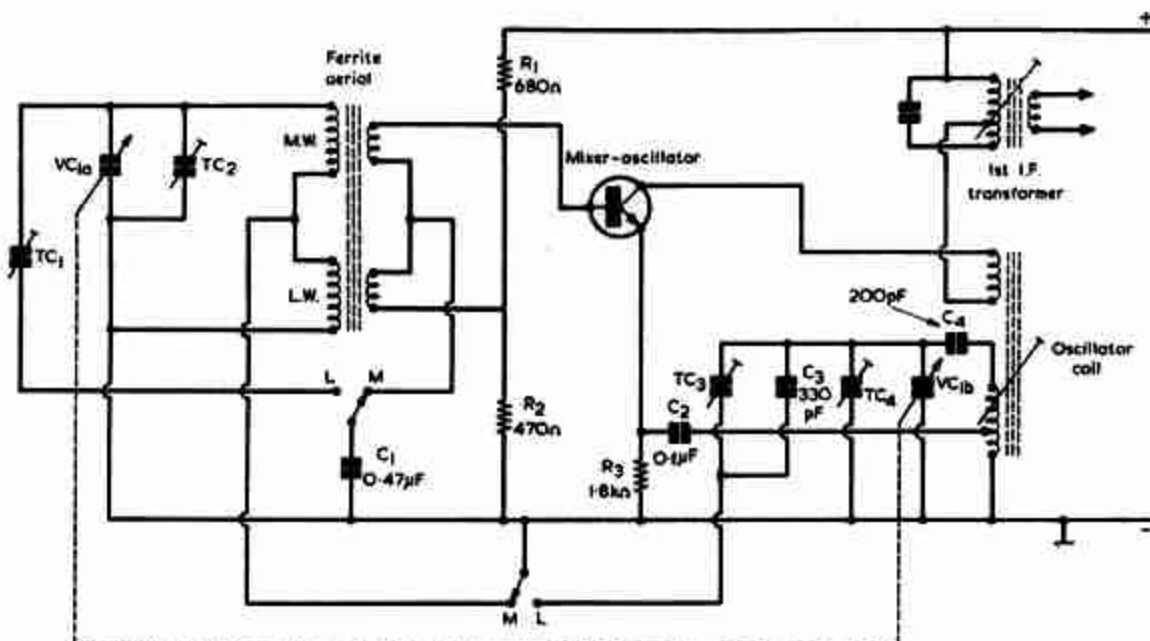


Fig. 4. Representative medium and long wave mixer-oscillator circuit as encountered in less expensive receivers. The most important point to note is that, on long waves, additional capacitance is connected across the medium wave oscillator tuned circuit

MORSE IMPROVEMENT

C90 Cassette (A) 1-12 w.p.m. with simple exercises. Suitable for R.A.E. preparation. (B) 12-24 w.p.m. computer produced professional level operator material including international symbols.

Price each: complete with instruction and exercise booklets £4.50 including postage.

Morse Key and Buzzer Unit suitable for sending practice and DIY tape preparation.

Price £4.50 including postage.

Overseas Airmail £1 extra.

MHEL ELECTRONICS (Dept. R)

12 Longshore Way, Milton,

Portsmouth (UK), PO4 8LS

THE

MODERN BOOK CO.

Largest selection of English & American radio and technical books in the country

18-21 PRAED STREET

LONDON W2 1NP

Tel: 01-402 9176

GAREX

V.H.F. Receivers SR-9 for 2-metres F.M., fully tunable 144-148MHz. 2-speed slow-motion dial, also 11 atal controlled channels. Compact, sensitive, ideal for fixed or mobile listening. Built-in L.S., 12v D.C. operation £57.35 inc. VAT. Crystals, if required: £2.50 each. All popular 2m. channels in stock. Marine band version (156-162MHz) £57.35 (atals £2.79). Mains psu for above £11.25. Credit terms available, s.e.s. details.

Amplified Mobile Extn. Speaker boosts audio from small receivers. Single compact unit. 12vDC built-in 6W amplifier, with leads and jack plug. 4-8 Ω input £11.25.

Amplifier only from above £2.70.

Neons min wire and 55p/10: £4/100 Slide switches min DPDT 18p ea: 6: 14p Resistor Kits E12 series, 22 Ω to 1M Ω 57 values 5% carbon film, 1W or 1/2W Starter pack, 5 each value (285) £2.95

Mixed pack, 5 each 1W - 1/2W (570) £5.40

Standard pack, 10 each (570) £5.40

Giant pack, 25 each (1,425) £13.25

I.C.'s (new) 7410 25p CD4001AE 25p

SN76660 75p NE555 55p 723(TO5) 75p

709 (TO5) 741 (DIL-8) Op.amps 30p:

BNC Cable mtg socket 50 Ω 20p:

5: 18p PL259 UHF Plug & Reducer 68p:

5: 60p: SO239 UHF Socket panel mtg.

55p: 5: 45p Nicad rechargables physically equiv. to zinc-carbon types: AAA

(U16) £1.84: AA(U7) £1.20, (CU11) £3.16:

(DU2) £4.94: PP3 £6.20 Any 5: less

10% Any 10: less 20%.

We stock V.H.F. mobile series,

s.e.s. details.

Distributors for J. H. Associates Ltd.

(switches and lamps)

PRICES INCLUDE UK POST, PACKING & VAT

Mail order only Sole Address:

GAREX ELECTRONICS

7 NORVIC ROAD, MARSWORTH,

TRING, HERTS HP23 4LS

Chaddington (STD 0296) 888884

CROSS MODULATION

"Is that mixer-oscillator circuit you've shown me given in all medium and long wave receivers?"

"You'll find the same basic approach in most," replied Smithy.

"The main variations will be in the way the ferrite rod windings are switched into circuit on the two bands. But you'll nearly always find that, on long waves, extra capacitance is added across the oscillator tuned circuit. Whereupon, once again, the medium wave band has to be aligned first."

Dick grinned.

"Do you realise," he said, "that all this discussion has arisen just because that little radio I serviced had image frequency whistles on it!"

Despite himself, Smithy grinned also.

"I can see that I've fallen into the usual trap," he chuckled. "Still, if I've given you some idea on how to avoid image interference on a.m. receivers the time has been well spent. I'd suggest you take that set you fixed back to your bench and give it a full line-up on medium and long waves before you consider it properly serviced."

"Okay-doke, Smithy."

A thought suddenly occurred to Smithy.

"Before you go," he remarked, "let me tell you about another sort of radio interference. This one disappears when the required signal ceases transmission!"

"Come on, Smithy. You're pulling my leg."

"No, I'm not. It's a form of interference which is mainly troublesome on communications receivers and which can cause some real design headaches. It's known as cross modulation interference."

"Cross modulation?"

"That's right. A strong a.m. signal can cross modulate another a.m. signal if they're applied to an amplifier stage which doesn't have a linear characteristic. If it has a non-linear characteristic the stage distorts the signal it amplifies, and this allows the two signals to beat together so that one cross modulates the other."

"I'm a bit lost here," confessed Dick. "Give me an example."

"All right," said Smithy obligingly. "Imagine you have a real super-duper communications receiver with two r.f. stages. Say it is tuned to 10MHz on the short wave bands, and that the serial input tuned circuit has a useful selectivity of about 500kHz on either side of the re-

quired signal. The selectivity improves as you proceed through the set. After the first r.f. amplifier it is about 100kHz and after the second r.f. amplifier it is down to about 20kHz. Following that it goes through the mixer to the i.f. amplifier, whereupon the selectivity can be kept down to a very low figure." (Fig. 5 (a).)

"I'm with you so far."

"Well," continued Smithy, "let's next assume that the required signal at 10MHz is weak and that there's a whacking great broadcast transmitter pumping out a signal nearby at 10.3MHz. This will get through to the first r.f. amplifier quite easily and, if this amplifier has a non-linear response, the strong signal will then cross modulate the weak one. There is no way in which you can remove that cross modulation after it has occurred at the first r.f. amplifier, even if the subsequent effective selectivity is nearly down to zero frequency on either side of the required signal. Cross modulation interference can be recognised because it disappears when the required signal goes off the air." (Fig. 5(b).)

"Blimey," said Dick, impressed, "that's something to think about. How d'you get over the trouble?"

"The only solution is to design the receiver so that all the amplifier stages in the early part of the receiver have very linear characteristics. Funnily enough, nobody worried too much about cross modulation in communications receivers in the old valve days, because valves can easily be made to have quite linear characteristics. Cross modulation only started to cause real unhappiness when the communications receiver designers changed over to transistors."

END OF SESSION

"Well," said Dick happily, "at least communications receiver design isn't something which need trouble us too much here in the Workshop."

"True, true."

"In fact, we need not get at all uptight or angry about cross modulation."

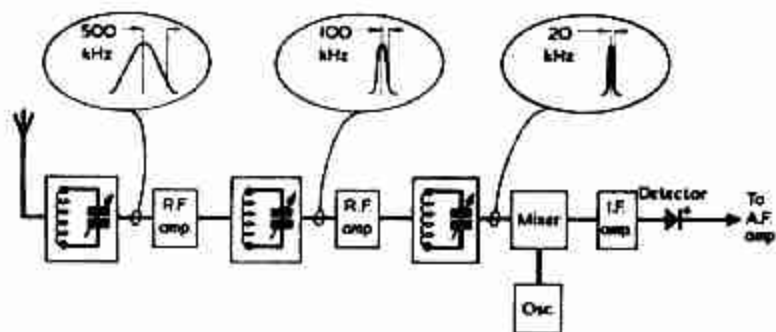
Smithy sighed.

"And we can cheerfully whistle our way through second channel interference."

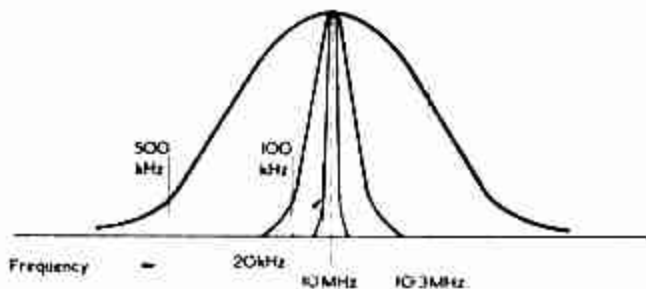
Smithy rummaged around on his bench.

"On reflection," persisted Dick mercilessly, "all we have to do is to present an acceptable image!"

Whereupon Dick ducked expertly



(a)



(b)

Fig. 5(a). The selectivity offered by a communications receiver with two r.f. amplifier stages increases after each tuned circuit

(b). The selectivity curves of the receiver superimposed on each other and centred on a desired reception frequency of 10 MHz. If, due to non-linearity in the first r.f. stage, an interfering signal at 10.3 MHz cross modulates the 10 MHz signal, the interference cannot be removed by the subsequent tuned circuits even though they reject the 10.3 MHz signal itself

as the 2,200 μ F 25V. Wkg. electrolytic sailed harmlessly past his right ear, after which he carried the

medium and long wave receiver back to his bench for a full and final re-alignment. ■