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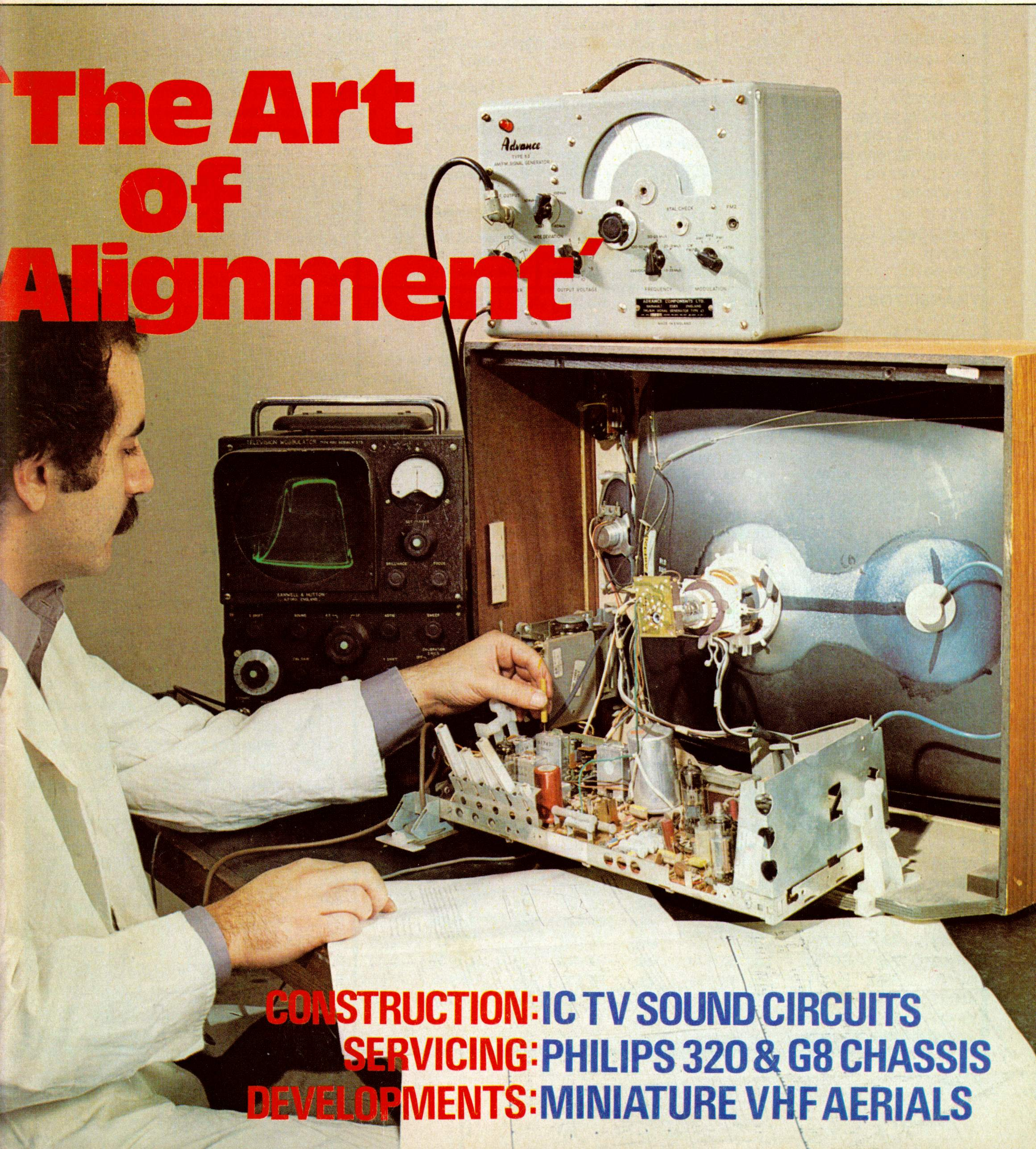
TELEVISION

SERVICING·VIDEO·CONSTRUCTION·COLOUR·DEVELOPMENTS

'The Art of Alignment'



CONSTRUCTION: IC TV SOUND CIRCUITS
SERVICING: PHILIPS 320 & G8 CHASSIS
DEVELOPMENTS: MINIATURE VHF AERIALS

The Art of Alignment

Part 1

Harold Peters

ONE of the earliest servicing skills was alignment, something one had to do quite often to the sets of years ago. It seems odd to the writer that this skill is so little used today. Maybe this is due to the lack of any standard work on the subject, especially one which starts from scratch. If you are shy when you have to face set realignment, wish you could handle a sweep generator and talk glibly about 39·5dB or 26dB traps, or wonder why a tweak on L28 improves the sound, then this is for you. Starting with superhet theory we shall be as basic as possible, with only the bare minimum of mathematics. We'll then look at tuned circuits of all types, the tools and equipment required for alignment, and end up with enough practical examples to enable you to tackle almost any set – or at least to understand what the service manual is getting at.

Service Manual Instructions

Since service manual instructions are guaranteed to put you off before you start, let us try to dispose of them as a major source of initial worry. Manuals originate from the laboratory at the setmaker's factory, and as all setmakers have their own ways of going about things their manuals all differ in the alignment methods specified and the equipment quoted. It's more than possible that the technical writer responsible for the instructions given in the manual has never tried the alignment out under field conditions with cheap gear. It's equally possible that the alignment procedure as written cannot be performed at all, having been adapted without trial from a group of factory instruction sheets relating to a particular production test rig. It could even be a student's translation – unchecked – from German or Japanese. So if you can follow the manual only with difficulty you are probably not alone. By getting yourself wise to the ways of i.f. strips however, so as to be able to understand the purpose of the instructions, you are well on the way to getting good pictures and sound. To square one then, the "Ohm's Law" of alignment and superhet theory – this establishes why we need to align at all.

Fourier's Theorem

The "Ohm's Law" of alignment, Fourier's Theorem, asserts that any complex waveform can be broken down into a fundamental sinewave and its harmonics (Fig. 1). Our complex waveform is the picture signal from the local transmitter, and its fundamentals are the r.f. carrier wave and the studio picture which is modulated upon it. For our purposes we can shuffle Fourier's Theorem round the other way, to produce the law of mixing – "if any two frequencies are mixed together, the resultant complex waveform will contain those two frequencies as well as their sum and their difference".

From Camera to TV Screen

This mixing process occurs three times between the camera and the eye of the viewer: first at the transmitter, then in the receiver mixer, and finally in the vision detector. We'll follow one such signal (Fig. 2) all the way. For ease of the necessary mathematics we choose London's BBC-2 channel 33 and assume its video modulation to be 5MHz – this represents the upper end of the video spectrum nicely rounded off – and hope you will accept that what works for 5MHz works for all the intervening frequencies as well. Also, to make the figures easy we'll ignore any sound modulation – its bandwidth is very small by comparison with the other frequencies involved.

Our basic signal then is:

> The channel 33 vision carrier at 567·25MHz, the sound carrier at 573·25MHz, and the vision modulation (0–) 5MHz.

Mixing at the Transmitter

The mixing that takes place at the transmitter therefore is:

> Two fundamentals, 567·25MHz and 5MHz, which produce their sum at 572·25MHz and their difference at 562·25MHz. Also the sound at 573·25MHz.

The sum and difference frequencies are called the upper and lower sidebands (more about these later) and as all five of the above frequencies make their way to the aerial the 5MHz signal is so far outside the tuning range of the circuits that it gets lost altogether while the difference frequency – lower sideband – is mopped up in a sort of

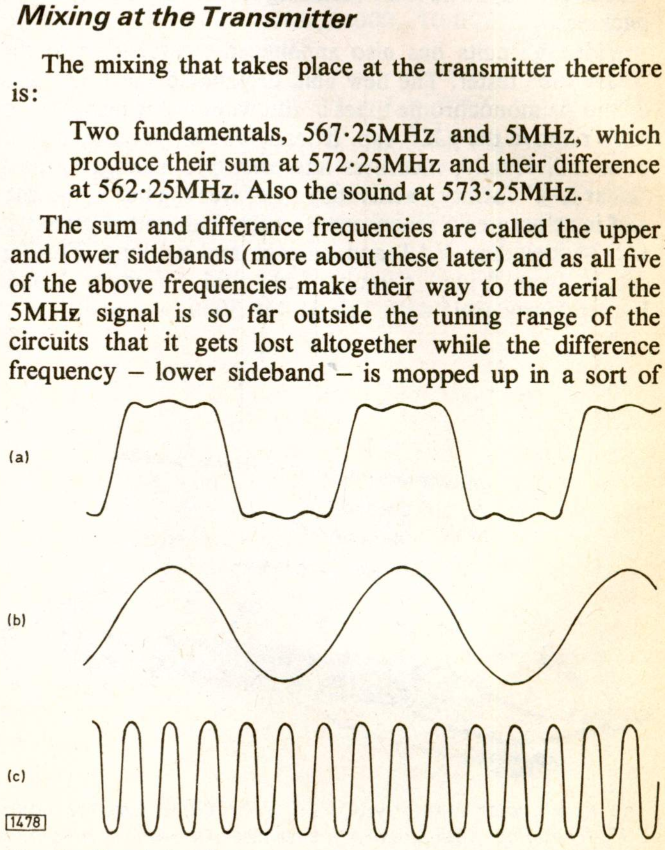
(a)
(b)
(c)


Fig. 1: Fourier's Theorem: a complex waveform (a) can be broken down into its component sinewaves (b) and (c).

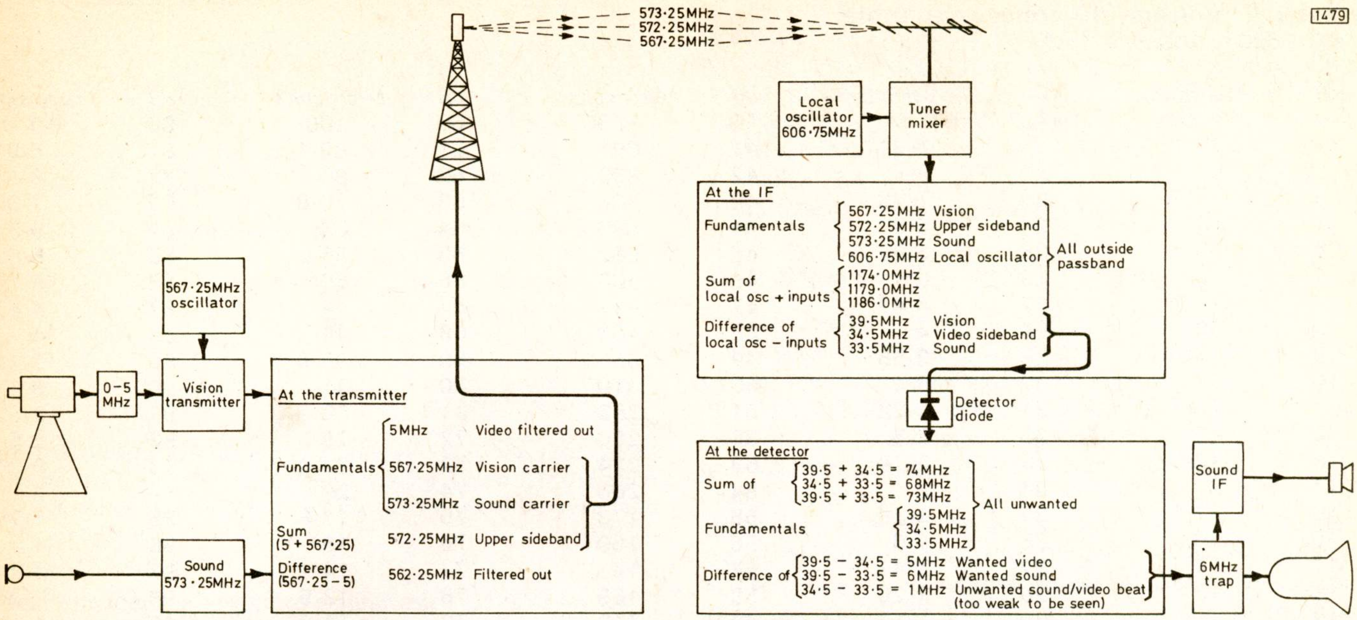


Fig. 2: Mixing processes, from the studio to the c.r.t. screen. To simplify matters the sound is shown unmodulated, i.e. as just a carrier, and the picture detail from the camera is simply a 5MHz sinewave.

electronic trombone called the vestigal sideband filter. The rest – 567·25, 572·25 and 573·25MHz (see Figs. 2 and 3) – are radiated by the transmitting aerial.

Action of the Tuner

At the receiver tuner we have another mixer stage where the three transmitted signals are introduced to a locally generated oscillation. This is kept at a frequency 39·5MHz higher than the selected vision carrier. In our case (ch. 33) it will be at 567·25 + 39·5 = 606·75MHz. The mixing process in the tuner thus gives us:

> Fundamentals at 567·25MHz and 606·75MHz, their sum at 1174·0MHz – these three we don't want any more – and their difference at 39·5MHz, the wanted signal or intermediate frequency (i.f.).
>
> Similarly the local oscillator mixes with the sound carrier. Here the fundamentals are 573·25MHz and 612·75MHz, their sum is 1186·0MHz – again all unwanted – and their difference is 33·5MHz, the wanted sound i.f.

If we place at the tuner output a tuned circuit which passes only frequencies in the 30-40MHz region, rejecting all others, only the difference frequencies will get through to the i.f. stages. Note incidentally that the sound and vision carrier frequencies change over, sound now being on the lower side of vision. This always happens when the local oscillator frequency is above the signal frequency as it invariably is, even on 405 lines.

After passing through several highly efficient fixed tuned circuits and at the same time receiving amplification a substantially larger i.f. signal is presented to the vision detector. We will assume that this is a diode. The mixing law still applies here.

You may have noticed that we conveniently ignored the vision sidebands when we described the action of the tuner. They are still present however, having themselves been transferred to the intermediate frequency range on either side of the 39·5MHz vision i.f. carrier. Thus the original 5MHz video signal, which became 572·25MHz (5 + 567·25) at the transmitter and the receiving aerial, mixed with the 606·75MHz local oscillator signal to give the unwanted sum and wanted difference frequencies 572·25 + 606·75 = 1179MHz and 606·75 – 572·25 = 34·5MHz respectively.

Vision Detection

So our maths finishes with all this stuff, i.e. the vision i.f. 39·5MHz (1), the sound i.f. 33·5MHz (2) and the 5MHz sideband 34·5MHz (3), being applied to the vision detector. Here the sum of (1) and (2) produces 73·0MHz, the sum of (1) and (3) 74·0MHz and the sum of (2) and (3) 68·0MHz – all of which we don't want so we filter out.

The difference of (1) and (2) is 6MHz, the wanted sound second i.f. The difference of (1) and (3) is 5MHz, the wanted video signal, and the difference of (2) and (3) 1MHz, an unwanted "tizz" which is likely to get right through to the screen because the video amplifier cannot differentiate between it and the 1MHz bars on the test card. In practice it's removed by keeping the 33·5 MHz sound i.f. 20dB down with respect to the 39·5MHz vision carrier (or 26dB from peak) and by fitting another sound trap to attenuate this still further after the 6MHz content has been successfully spirited away to the intercarrier i.f. channel.

In mentioning trap depths we have jumped ahead a little, and although some of you can juggle with decibels like they were PCF80s may we break off here to refresh the minds of those who are a little rusty on these units, since they are likely to pop up from time to time as we proceed.

The Decibel

The decibel is a unit normally used to compare power ratios on a manageable scale. Thus 10 × log (power 1/power 2)=power gain expressed in decibels. R.F. types usually use dBs to compare voltages across a common load, and since power is related to voltage by $W = V^2/R$ the formula becomes 20 × log ($V1/V2$).

For example if our output meter jumps from 1V to 2V and then to 10V the first increase is 20 log (2/1), or 20 log 2. The log of 2 is 0.3010 so 20 log 2 is 6·02 – near enough 6dB.

The second increase is 20 log (10/1) = 20 log 10 = 20 × 1·0 = 20dB.

Table 1: Voltage/dB conversion table.
(0-100dB to 100mV – 1μV)

dB	Millivolts	dB	Millivolts	dB	Microvolts	dB	Microvolts	dB	Microvolts
0	100	20	10	40	1000	60	100	80	10
1	89·1	21	8·91	41	891	61	89·1	81	8·91
2	80	22	8	42	800	62	80	82	8
3	70·8	23	7·08	43	708	63	70·8	83	7·08
4	63	24	6·3	44	630	64	63	84	6·3
5	56·2	25	5·62	45	562	65	56·2	85	5·62
6	50	26	5	46	500	66	50	86	5
7	44·7	27	4·47	47	447	67	44·7	87	4·47
8	40	28	4	48	400	68	40	88	4
9	35·5	29	3·55	49	355	69	35·5	89	3·55
10	31	30	3·1	50	310	70	31	90	3·1
11	28·2	31	2·82	51	282	71	28·2	91	2·82
12	25	32	2·5	52	250	72	25	92	2·5
13	22·4	33	2·24	53	224	73	22·4	93	2·24
14	20	34	2	54	200	74	20	94	2
15	17·8	35	1·78	55	178	75	17·8	95	1·78
16	16	36	1·6	56	160	76	16	96	1·6
17	14·1	37	1·41	57	141	77	14·1	97	1·41
18	12·5	38	1·25	58	125	78	12·5	98	1·25
19	11·2	39	1·12	59	112	79	11·2	99	1·12
20	10	40	1	60	100	80	10	100	1

To use, follow these examples:
26dB down on 10mV = 20dB + 26dB = 46dB = 500μV.
Stage unaligned gives 300μV, aligned gives 1mV: gain is 50dB – 40dB = 10dB.

So doubling a signal increases it by 6dB and amplifying it ten times is expressed as 20dB. Table 1 shows how to convert between millivolts/microvolts and decibels when comparing gain or attenuation.

Vestigial Sideband Transmission

When, some way back, we looked at the transmitter we mentioned that the 5MHz video signal mixed with the 567·25MHz r.f. carrier to produce two sidebands, at 572·25 and 562·25MHz. However complex the TV signal, these two sidebands lie symmetrically about the carrier, the lower one being a mirror image of the upper one. This means that the signal we followed would take up 10MHz of "airspace". There is not enough room for this if, with the "space" available, we are to have a four programme service with country-wide coverage. To economise we suppress the lower vision sideband – after all it's exactly like the upper one. This saves us 5MHz, and with the sound 6MHz away from the vision and a "no man's land" before the next channel enables us to have our u.h.f. channels 8MHz apart.

There are snags however. First it's impossible to chop off the lower sideband cleanly just below the vision carrier, and secondly it's necessary to reduce the vision carrier power by half (6dB!) because half the lower sideband power is still left. So the vision transmitter response is tapered off, starting at 1·25MHz above the vision carrier and ending, as shown, 1·25MHz below it. You will notice that the vestige of sideband below the carrier would exactly fill the gap above it on the h.f. side. It is this *vestigal sideband* system which is used on u.h.f. today, and all that it's necessary to remember is that the 8MHz channel spacing starts at the lower end, with vision carrier 1·25MHz in followed by the sound at 6MHz higher and with an 0·75MHz guard space before the start of the next channel. See Fig. 3.

You may now be thinking that it's a pretty tall order to ask a tuner to track all the way from ch. 21 to ch. 68 admitting only a chunk of frequencies 8MHz wide, so you will not be surprised to find out that the tuner response is pretty flat and that all the response curve shaping is done in the fixed frequency i.f. section where the response is adjusted to follow the shape of the transmitted signal fairly closely. This answers the question "why tune i.f.s?".

The Ideal Response Curve

The receiver's "response curve" is simply a graphical representation of output plotted against frequency – usually as seen at the vision detector. If it conjures up an impression of a complicated hook-up involving oscilloscopes and sweep generators, remember that you can produce one easily enough with just a simple signal generator and a voltmeter – by plotting the results on graph paper with an ordinary lead pencil. More of this anon.

Right now let's look at the response curve carefully to see what the shaping in the i.f. stages involves and why the particular frequencies chosen are used. This is because: (1) We have agreed internationally to use an i.f. bandwidth of 30-40MHz. (2) We still use channel 1 for 405-line transmissions. (3) The vision i.f. carrier is 6MHz above the sound carrier on 625-lines. (4) The space between our vision carrier and the next channel's sound is 2MHz.

Selecting the IF Carrier

If you think about it, the only fixed parameter above is item (2). The channel 1 sound carrier is at 41·5MHz, just outside the i.f. band. This frequency allocation is a relic of the good old pre-war days of "Ally Pally" (who remembers Cabaret Cruise?) and is still used today by Crystal Palace, Divis, Redruth and others in sufficient strength to cause interference. Obviously a trap has to be fitted in the receiver's i.f. channel to attenuate this frequency, and what better than to kill two birds with one stone by using it to suppress the adjacent channel sound i.f. on 625?

Having fixed this point, all the other frequencies fall into place. The vision carrier comes 2MHz lower at 39·5MHz (half way up the slope in Fig. 4(a), at the right-hand –6dB point). The slope of the curve around the 39·5MHz part of the response should mirror that of the vestigal sideband

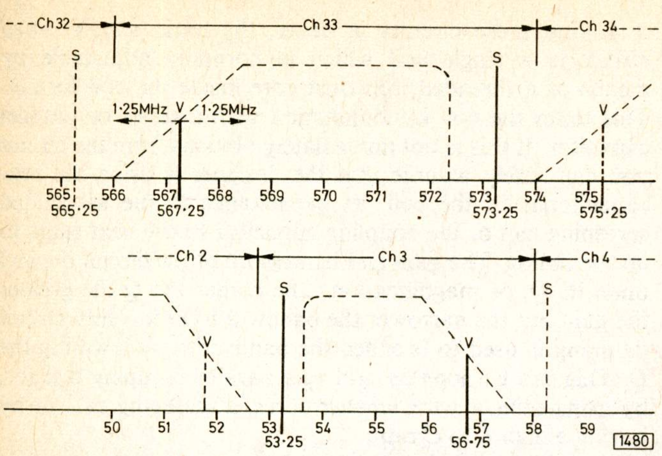


Fig. 3: Vestigial sideband transmission. Top, the channel 33 sound-vision signal disposition, showing how a 13MHz quart is squeezed into an 8MHz pint pot. Below, the 405 system to the same scale.

transmission, levelling off to a minimum 1·25MHz higher.

On the lower frequency side, i.e. to the left in Fig. 4, we see a level top and then a more gradual fall-off towards the sound carrier than at the transmitter. The 33·5MHz sound carrier is seen to sit on a shelf (steady!) at 26dB below peak or 20dB (one tenth) below vision carrier. We need to stop the sound signal appearing on the screen, yet we need to preserve some sound in order to get a 6MHz intercarrier i.f. output from the vision detector. Experience shows that 26dB of attenuation is just about right.

At 2MHz lower still (31·5MHz) another trap is used to remove any trace of the vision carrier of the next channel higher up.

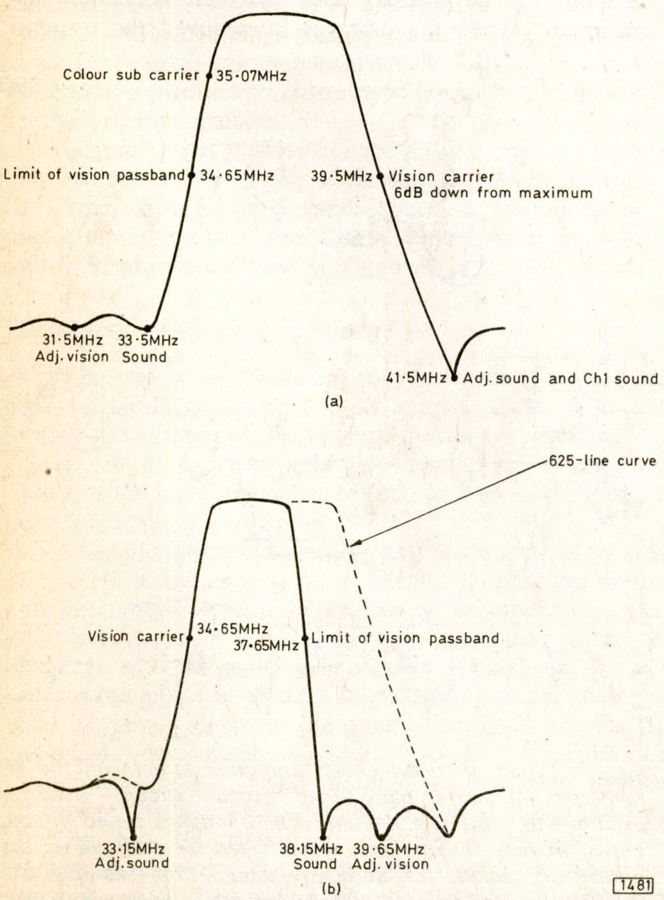


Fig. 4: Ideal i.f. response curves, (a) 625-line system, (b) 405-line system.

Two other "markers" are shown in Fig. 4(a), and although they are sitting in typical positions their precise location varies with the set and its designer's whim. The colour subcarrier comes at 35·07MHz (39·5–4·43MHz) and there is a "bandwidth" marker at 34·65MHz. If this particular frequency rings a bell, it is the invariable choice of vision i.f. for 405 lines and is also a convenient indication of satisfactory bandwidth at 625 lines.

Conditions on 405 Lines

Before looking at Fig. 4(b) go back to the lower half of Fig. 3 where the 405-line transmitter spacings have been set out on the same scale as our channel 33 example above. Note the differences: sound is 3·5MHz *below* vision, the channels are 5MHz apart, with 1·5MHz between the vision and adjacent channel sound carriers, and the slope of the vestigal sideband is 0·7MHz either side of the carrier instead of 1·25MHz. Two other differences also affect the alignment. First the sound is amplitude modulated (a.m.) so we cannot use the intercarrier sound technique. This obliges us to use the full 38·15MHz sound i.f. and hope that the tuner doesn't drift. Secondly the vision is positively modulated, so the sound/vision ratio will vary with picture content.

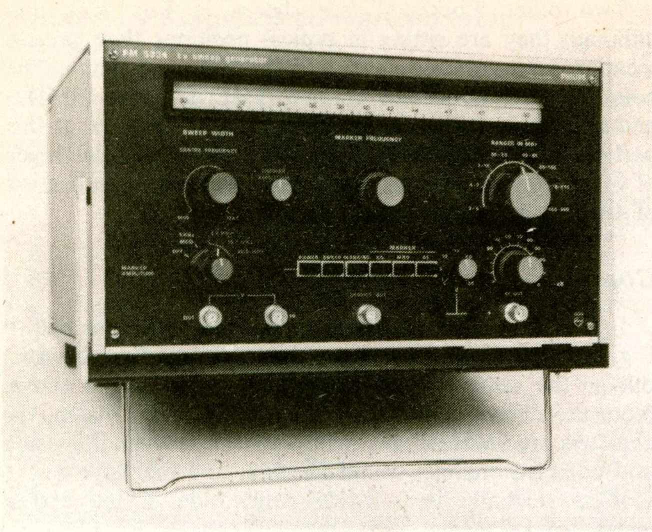
Because the sound and vision signals change over places in the mixing process in the tuner, the i.f. response curve is the reverse of that on 625. We have shown it tucked into the 625 curve (dotted). With the vision carrier at 34·65MHz – 6dB down – at the left-hand side, the sound carrier is therefore $34{\cdot}65 + 3{\cdot}5 = 38{\cdot}15$MHz while the vision carrier of the next channel down is another 1·5MHz on at 39·65MHz. The other possible source of interference, the next sound channel up, is at 1·5MHz below vision i.f., i.e. 33·15MHz. So traps are fitted at 33·15, 38·15, and 39·65MHz and you will note that the sound trap at 38·15MHz is as deep as the rest, for we no longer require any sound left at the vision detector to provide the intercarrier signal. 40dB or more rejection is in fact needed for sure-fire killing of all sound-on-vision.

We deliberately ghosted in the 625 curve as most old sets are dual-standard ones. As Vivian Capel described in the April 1972 issue, most 405 only sets can be aligned by eye. Notice how the 625 response takes up the 405 shape by simply switching in three extra traps. Notice too that the 33·5MHz 625 sound trap (the one that gave the shelf at 26dB) has been left in. This is common practice since with a vestigal sideband roll-off of only 0·7MHz below the vision carrier the transmitted signal ends at $34{\cdot}65 - 0{\cdot}7 = 33{\cdot}95$MHz, almost half a megacycle in front of the trap which therefore will not influence the curve shape much. This is why dual-standard sets must be aligned by the book: adjustments made on one system are bound to affect the other.

Intercarrier Sound

Why do we use the intercarrier sound system on 625 lines? Imagine that we didn't and that the set had a true 33·5MHz sound i.f. strip. This could be done just as easily. The i.f. strip would be sharply tuned, with a bandwidth of 100kHz at the most.

Unfortunately however most tuners used on u.h.f. drift much more than this during the first half hour of use, while most of the push-button mechanisms do not have a reset accuracy anything like as good. So if you turned the set on for the news you would have to get up to it again before the weather forecast. To avoid this we take advantage of the



The Philips PM5334 television sweep generator.

two – vision and sound – crystal controlled transmitters which, give or take a co-channel offset, are exactly 6MHz apart. The signals will stay that way right through the receiver regardless of the detuning the mechanism produces. It makes sense therefore to pick off this 6MHz beat at the vision detector and to amplify it further as the sound i.f. With it goes an awful vision buzz, but because this is a.m. while the sound is f.m. the limiting action of whatever type of discriminator you use will kill it off – provided you have kept the signal ratios right at the beginning. The 405-line a.m. sound, usually amplified at 38·15MHz, would drift just as badly if it were on u.h.f.: but it isn't, so the need does not arise.

Continental Conditions

Not having a pre-war 405-system to tie them down to channel 1 most Europeans use 625 lines on v.h.f., as well as u.h.f. The channel spacing is 7MHz on v.h.f. and 8MHz on u.h.f. where the channel allocations are just like ours. Their sound is 5·5MHz from vision, however, which accounts for the buzzing we get on foggy nights, and the vision i.f. carrier is usually 38·9MHz. This makes the rest of the i.f.s: vision carrier 38·9MHz; sound carrier 33·4MHz; colour sub-carrier 34·47MHz; adjacent sound 40·4MHz v.h.f., 41·4MHz u.h.f.; adjacent vision 31·9MHz. Notice that they are not tied like we are to 41·5MHz.

Frequently imported sets arrive aligned to these frequencies, and in a minimum-effort exercise the importers simply adjust the 5·5MHz sound to 6MHz and leave the rest untouched. This can give rise to patterning or interference in some areas.

So much for basic theory. Let's move towards the practical side of things by next taking a look at the types of circuit used to provide the required receiver response.

Tuned Circuits

The five basic types of tuned circuit are shown in Fig. 5. It's sometimes a job to recognise them as such however due to the way in which they are drawn in circuit diagrams. When trying to understand a circuit, first attempt to subdivide the tuned circuits into signal circuits and traps. The former enable the wanted frequencies to pass from one stage to the next, whilst the latter reject unwanted sections of the frequency spectrum.

Taking these circuits in order, the basic *simple tuned circuit* is a single coil which is normally adjustable by means of a threaded iron dust core inside the coil former. This tunes the coil in conjunction with a series or parallel capacitor. If this is not immediately obvious from the circuit you can safely assume that the designer is using the self-capacitance of the coil, its capacitance to the associated screening can or the coupling capacitor to the next stage to do the tuning. The gain and bandwidth of the circuit depend upon its Q, or magnification. The higher the Q the greater the gain but the narrower the bandwidth. Frequently circuit damping is used to broaden the bandwidth by lowering the Q. This can be done by adding a parallel damping resistor, by using thinner wire, smaller cores, a screening can, or by having a high L to C ratio.

To broaden the bandwidth without losing gain a pair of high Q coils, both tuned to the same frequency, can be mounted close together so that they affect each other. This coupling combines the response curves of the pair to give a single response curve with two humps and a trough at the centre frequency. The ideal flat topped bandpass response can be nearly attained by carefully varying the coupling in design. In some cases this becomes an alignment adjustment.

Various forms of bandpass coupling can be encountered. There is mutual coupling by coil proximity (ask your Dad!). Mutual coupling by a ferrite or dust core – probably swivellable. Top capacitance coupling – see Fig. 5(b). Bottom capacitance coupling – the coaxial lead connecting tuner output to the i.f. deck for example. And bottom inductive coupling – a small winding common to both coils.

The test for a true bandpass design is to pass a signal through at centre frequency, damp the secondary heavily and tune the primary for maximum. Then transfer the damping to the primary and tune the secondary for maximum. When the damping is removed the response

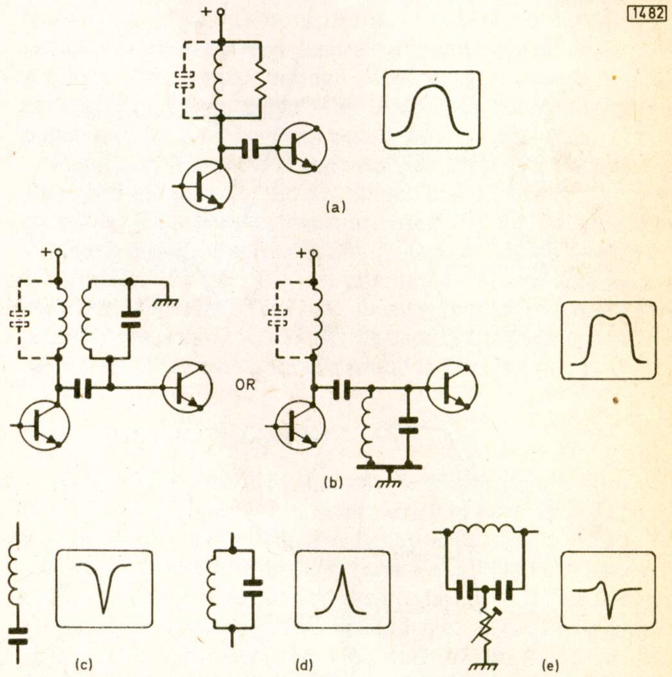


Fig. 5: Types of tuned circuit and their effects on the i.f. response. (a) Simple flatly-tuned resonant circuit – used for example to drive the detector. (b) Bandpass tuned circuit, drawn in two conventional ways. Used for example as the middle i.f. stage. (c) Series rejector – for example the 33·5MHz sound trap. (d) Parallel rejector – used as a 6MHz intercarrier sound rejector/take-off point for example. (e) Bridged T trap – 41·5MHz rejector for example.

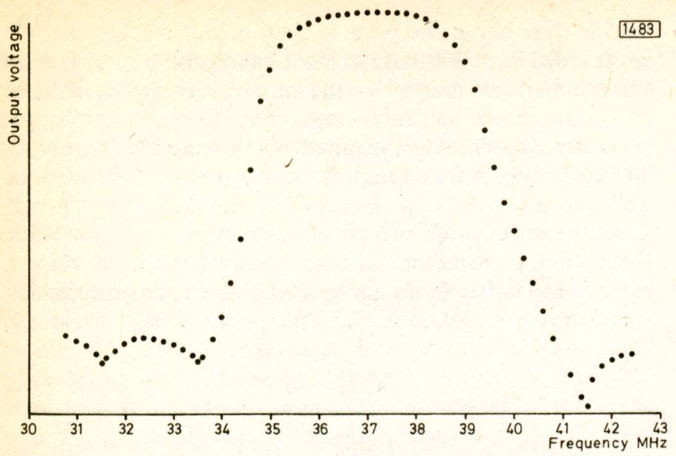


Fig. 6: Plotting a response curve using a simple signal generator and output meter. If the output voltage is plotted against the input frequency from the generator, say every 200kHz, a response curve can be drawn as shown above.

curve should lie symmetrically around the centre frequency.

Series rejectors are a means of removing an undesired spot frequency, such as own or adjacent sound channels. They work by presenting a dead short at the required frequency. The Q of the circuit determines the depth of the rejection and is fixed in design by adjustment of the L/C ratio of the components.

Parallel rejectors work the opposite way, showing a high impedance at the chosen frequency. They are usually found in emitter or cathode circuits when heavy negative feedback at a particular frequency is required.

When a very deep rejection is needed a bridged T trap – see Fig. 5(e) – is used. This takes the form of a balanced bridge. Adjusting the coil determines the frequency while adjusting the resistive leg determines the Q or trap depth. Suckouts of the order of 60dB can be obtained in this way, but not without modifying the overall response shape – the high Q produces a pop-up on one side of the trap. This will steepen the side of a response curve or make it necessary to provide further trapping.

There are other means of shaping the response – usually not self-evident by looking at the circuit – but once a panel has been checked on a sweep generator their purpose is made clear. This is all the more reason for us to press on to the more practical aspects of alignment.

Signal Generator Alignment

Time was when alignment was universally carried out with a signal generator and an output meter. Although sweep generators and oscilloscope displays have ousted the other two in common use, they nevertheless remain the tools of the basic alignment method as well as providing a check upon your sweep gear.

In the signal generator and output meter method (Fig. 6) an output meter (such as an Avometer) is connected across the vision detector load resistor, set to read about 2-3V d.c. The set's a.g.c. is immobilised by a fixed bias supply or battery, and the signal generator is applied sequentially across the inputs to the i.f. stages, starting at the back end and working forward to the tuner. The tuned circuits are adjusted appropriately as you proceed – rejectors for minimum reading, signal circuits for maximum. When complete, the response curve can be plotted as a graph – as in Fig. 6 – by reading off the output throughout the passband at every 0·25MHz say. This is a laborious method, and it does not permit you to see what effect any one adjustment has on the coils that have been aligned so far. The curve plotted should however agree with the trace of the same set as seen on a sweep generator. This gives a useful check on the test gear.

Sweep Generator Alignment

Although used exclusively in set manufacture the sweep generator (wobbulator) and display ('scope) method of alignment is viewed by most service engineers with some trepidation. And justifiably so, as it is often possible to produce any curve shape you wish merely by altering the test rig and leaving the set alone.

The sweep generator replaces the signal generator used in the previous method while the display oscilloscope replaces the meter across the vision detector load. By applying the oscilloscope's X sweep voltage to some device inside the sweep generator, such as a varicap diode, the frequency of the sweep generator's output can be varied right through the i.f. passband in perfect step with the horizontal scan of the oscilloscope. If the sweep generator's output voltage is maintained constant regardless of frequency, then any variation in the receiver's output will be due to changes of i.f. gain with frequency. Thus the display will plot continuously the graph shown in Fig. 6 as the familiar response curve. To be able to see the entire vision i.f. response at once makes alignment more accurate and simple.

A snag for retailers and field engineers is that for every different make of set the manufacturer's own favourite brand of testgear will be specified. Don't let this put you off however, because once you have set up your own test rack it will tell you all you want to know about anybody's i.f. strip without much additional effort. The only variables you will encounter will be the probes for injecting and extracting the signals, the bias arrangements, and the damping resistors. Happily these seem to get handed down from one generation to the next.

Sweep Speed

Too high a sweep speed will distort the trace at just about every stage in the hook-up – the varicap may not be able to follow the voltage change from the 'scope, the set may intermodulate, and the time-constants in the detector and the probes could smooth out or phase shift the result. Conversely, too slow a sweep rate produces a flicker or even makes only part of the trace visible, it enhances noise, and it reproduces spurious signals. A good compromise is 50Hz, and there is no reason why the mains should not be utilised via a transformer to feed a sweep voltage to the wobbulator and give the 'scope its X scan at the same time.

Markers

There was a time when an error of 500kHz would not matter all that much. Not so today. As we saw earlier, the 6MHz difference between the vision and sound transmitter outputs is used to give us our sound i.f., while it is important to sit the adjacent sound trap at 41·5MHz in areas still getting channel 1. We also noticed how important it is to sit vision carrier exactly 6dB down from peak, and to shape the other side of the curve correctly to avoid intercarrier buzz and sound-chroma beats.

We didn't get round to mentioning automatic tuning control (a.f.c.), so we had better do so now. By detuning the early u.h.f. monochrome sets you used to be able to take up a vast number of alignment errors. This is not possible with colour sets, and if there is a.f.c. it will bring your aligned strip right back to the way you have mistuned it once the user has let go of the tuning button. Accurate markers then are a *must*.

Consider buying a couple a crystals and making them up into simple one-transistor oscillators in order to set up the sweep markers accurately. The two most useful are a third overtone 39·5MHz (basic 13·166MHz) and a 6MHz crystal for exact sound spacing. The harmonics of this will also give you checkpoints along the i.f. spectrum at 30MHz 36MHz and 42MHz.

You can introduce markers on to the display in many ways. The simplest is to add a little of the crystal generator output or signal generator output to the input together with the sweep. This has the disadvantage of raising the baseline of the trace – see Fig. 7 (a) – due to a d.c. voltage which is proportionate to the beat amplitude being produced at detection – a plain sweep produces very little d.c. at the detector. For the same reason this kind of marker will almost disappear in a trap, making the trap difficult to set with any precision.

More sophisticated sweep generators include marker amplifiers to produce pulses which can be applied to the 'scope's Z input to give the display a bright-up or gap depending on the pulse polarity. Such "bright-up" markers are the easiest to work with. Another type of marker, the "birdy bypass", produces a birdy at an external socket for adding to the display input after detection. This removes the disadvantages of the simple "birdy" mentioned above, keeping the baseline steady.

Bias Supplies

Sweep alignment requires that the a.g.c. line is clamped to a fixed bias. Otherwise the a.g.c. will fight the sweep generator and try to straighten out the response. It cannot win, due to the small amount of d.c. we have just said is present at detection from a sweep signal. Alignment is normally carried out at about the level required to transfer the a.g.c. to the tuner ("crossover") about which more anon. Trying to align at maximum gain makes for a noisy trace with much instability.

The majority of bias needs can be met by using a 1·5V or 4·5V battery with a potentiometer across it. If a small variable power supply, 0-20V positive or negative, is available however this is better. Often you can use a transistorised i.f. strip's own l.t. supply by clipping a 5kΩ potentiometer from l.t. to chassis. Observe the polarity demanded by the design of the set, and take care with transistor strips using forward a.g.c. – as most do. These give the required trace size with two settings of the potentiometer, one when forward bias is applied and the other with reverse bias. You will never get the strip to align if you are on the wrong one.

Sweep Generators

The number of readers with access to a Polyskop can probably be counted on the fingers of one foot. In fact carefully disguised enquiry puts the number of workshops with any sort of sweep generator as "small", and those that use the thing regularly as "smaller still". Apart from the very expensive instruments made for the manufacturing side of the industry, the selection of generators available is virtually non-existent. Some of you may still have a Telecheck from the old 405 days. These will still function on 625 if you recall that the i.f. band covers the same group of frequencies but reversed.

Philips have introduced their PM5334 into this gap in the market. For about the price of their colour bar generator it covers 3MHz to 860MHz in eight bands and has three fixed and one variable marker — the latter can be modulated and its output made available separately for use as a signal generator as well. Also included is a floating bias supply, 0-30V at 50mA, hefty enough for use on radio repair work as well.

At the lower price end of the scale there are various kits. Even less expensive but not too accurate is the adaptation used by the writer of an unrequired pattern generator which tuned down to channel 1. The pattern was discarded,

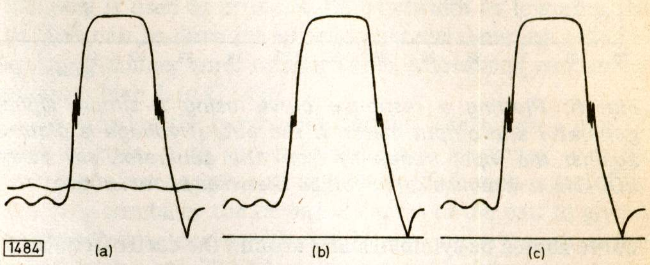


Fig. 7: Different types of sweep marker. (a) Birdy markers – note the rise in the base line, proportional to the marker's amplitude. (b) Bright-up markers, using the 'scope's Z modulation input. (c) Birdy bypass markers.

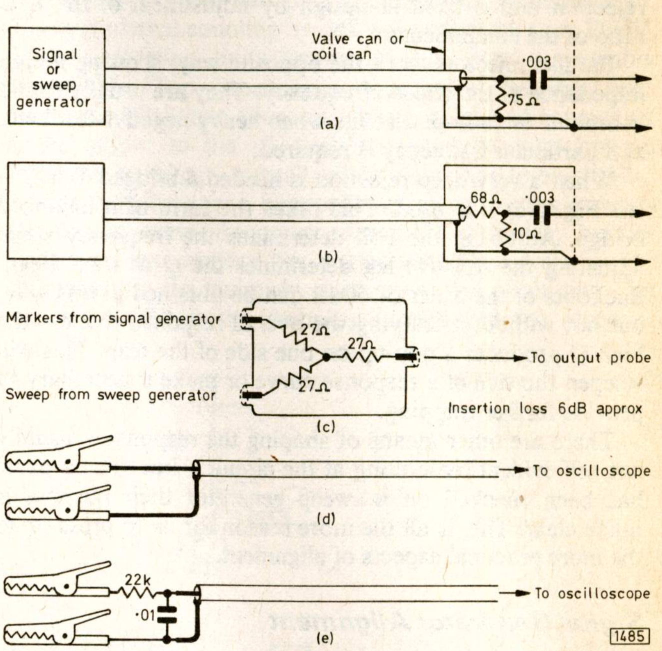


Fig. 8: General purpose probe details. (a) Simple probe suitable for most valve stages. (b) Divide by eight probe to present the low impedance often required when working on transistor circuits: 800µV from the signal generator yields 100µV at the probe end. (c) Mixer unit to enable markers to be added without upsetting the impedance of either feed. (d) Simple take-off probe. (e) Take-off probe with filter to remove spurious beats.

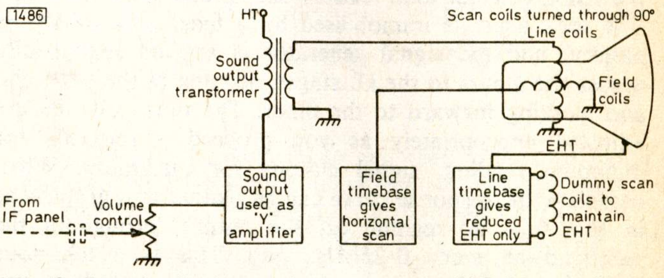


Fig. 9: Simple display made from an old 405-line receiver – see text for further details.

making the output c.w., and a primitive varicap diode consisting of a doctored loudspeaker with metal foil across the centre gauze dust filter was fitted across the r.f. oscillator tuning capacitor. A variable 50Hz supply from a 6·3V heater transformer vibrates the speech coil, with the result that the bit of foil and the speaker body become a variable capacitor at mains rate. This modulates the "signal generator" at mains rate, sweeping it through the i.f. band, whilst the full 6·3V drives the scope X amplifier in step. For the experimenter willing to try it this will give acceptable results on sets of some age, but we would hesitate to approve its use for colour. Nevertheless it's an excellent introduction to sweep alignment and an ideal tool with which to learn the craft at minimum cost.

Signal Probes

To accommodate all the probes specified in all the manuals would take a fair sized nail in the wall. Usually however you can manage with half a dozen. You need one for valve sets, one for transistor i.f.s and two for the tuner i.f. points. Add to this list a mixing unit to add the markers. There is no special magic about probes. They exist to ensure that the sweep generator, looking out, sees 75Ω. At the same time their loading on the circuit being adjusted should not tilt the trace. For most modern transistor work a low input impedance is desirable and the ÷8 probe shown in Fig. 8 (b) is favoured.

Displays

Most oscilloscopes provide suitable displays, but the smaller the screen the harder it is to see to set traps well. Depending on the hook-up, the X deflection may need bringing out to drive the sweep generator, or switching off so that the sweep generator – or 50Hz – can drive it. If the mains is used to drive the sweep generator the flyback gets modulated as well as the forward trace, so it either needs blanking out or made "phase shiftable" so that both traces coincide. The ideal display size is 11in., and most commercial X-Y displays are this size. If you were thinking of having an attempt at the transductor sweep generator we have just described you might also be tempted to produce a display from a discarded TV set. An old 14in. set that still works is ideal. You substitute a dummy load for the line scan coils (see Fig. 9). This maintains the e.h.t. supply, at a reduced voltage. Turn the scan coils through 90° and use the field timebase to provide the horizontal scan. You can derive the sawtooth for the sweep from the field timebase or from a 50Hz heater transformer. The input from the detector of the receiver is fed to the volume control, and the output from the audio output stage is taken to the line scan coils instead of the loudspeaker. A mains isolating transformer must be included.

Display Probes

The simplest type of display probe (see Fig. 8 again) consists of a coaxial lead with crocodile clips at the receiver end. You may need a small series resistor to reduce loading effects, and possibly a 2,000pF capacitor across the coaxial lead to reduce noise and spurious signals.

These then are the tools of alignment, and before we proceed next month to their use may we utter a word of caution. Until you are thoroughly conversant with i.f.s, leave tuners severely alone.

CONTINUED NEXT MONTH

The Art of

THE ultimate aim is to have a bench at which you can align all the i.f. strips you work upon using one carefully set up group of equipment. There is no real reason why this should not be done. A basic alignment procedure carried out on sets of some age will always produce an improvement. If the main brand you work on has a practical, workable and understandable method in its manuals, then use it in preference to anything you read here since it is likely to follow on consistently from one generation of sets to the next. Try and spend a whole day just getting to know your way round the gear, using if you can a new set with good alignment to give you some idea of what to expect.

Hooking up the Gear

The basic equipment hook-up is shown in Fig. 1 and is the same for all sets. All test gear should be earthed, with correctly polarised mains leads, as a nasty punch is delivered from the combined charge on all the mains suppression capacitors. Isolate the work. As mentioned above check the operation on a set of known goodness, and double check by plotting a response graph as described last month, using a signal generator and meter. You may need to fit an inverting switch to the display if – as with the writer – you cannot work on upside-down traces. Iron out as many snags as you can. Huge markers may spoil the trace. If so remove the mixing unit and couple them in loosely. Try a small capacitor across the input to the display to clean noise off the trace.

Display Input

Take the display input from the vision detector diode which if wired with respect to chassis should be d.c. coupled to preserve the baseline. If the diode is up in the air, as in many dual-standard sets, blocking capacitors of the order of 0·1μF are needed in both inner and outer leads and the baseline will float up and down, involving constant resetting by the display Y shift. The Y gain should be set to take about 2V peak-to-peak from the detector and produce a full trace. Use a slow sweep rate (25-50Hz) or mains via a transformer as previously described.

Connecting the Work

To start off, try and get a strip which can be powered from the bench supply and has a convenient tuner test point. The one in our diagram is pure fiction but is like a number you could encounter. Starting off with a strip working in a mains-fired set can be disheartening, as little spikes of line timebase radiation will crawl up and down the trace like a chair lift. Once accustomed to them they do not bother you unduly. If you must use a set, ensure that the isolating transformer's wattage is adequate. Modern sets with thyristor power supplies saturate isolating transformers with the unwanted half-cycle, so although a set is rated at say 200W a 500W isolator may be needed for continuous running and an undistorted mains supply. Check that fitting an isolator doesn't alter the preset h.t. voltage if the set has one.

Alignment

Harold Peters

Part 2

Injecting the Signal

The short cut is to introduce the signal at the tuner i.f. test point and align right through. To do this is to run the risk of tilting the trace by the mere act of adding the probe. Today's tuners commonly demand a probe of 1pF or less, and this has to make contact with a component joint deep in the works via a little hole in the side. Earlier tuners were more gentlemanly and provided a spare feedthrough capacitor to which a probe of greater admittance could be connected. Suppose we start by doing this. We should get a noisy trace on the display, and a full sweep with the wobbulator attenuator set well down.

Biasing

We now apply bias from our battery or other unit via a series resistance of higher impedance than the signal but lower than the a.g.c. Typical values are 100kΩ for valves, 2kΩ for transistors. This should clean up the trace, and an increase in the wobbulator output of the order of 30dB should be needed to restore full trace amplitude. The trace should now look something like the one in the manual. It pays to get this bias setting right. Most i.f. strips are factory aligned at minimum gain, that is to say at a point where the signal is heavily attenuated by a.g.c. but where delayed a.g.c. has not yet been applied to the tuner. You can get these conditions by putting the strip under test back in its set which is receiving a strong pattern. Monitor the a.g.c. lines to both the tuner and the i.f. strip and adjust the input signal until the tuner is just not taking a.g.c. (i.e. the crossover point). Then apply your bias unit and adjust it for the same condition. You have now set the i.f. a.g.c. to the crossover point and can revert to the hook-up and look at the trace. Before we go on however a note on a.g.c. may help those who are rusty on this subject.

AGC for the Rusty

The purpose of a.g.c. is to sample a part of the signal which does not vary with picture content – usually the back porch or the sync tip – and produce from it a control voltage which can be used to make the output constant. In order that sets will work anywhere, an a.g.c. range of 70dB is required, i.e. the output should remain constant with inputs varying from 10μV to 30mV. The average tuner will manage about 20dB of this so the remaining 50dB of control needs to be applied in the i.f. strip. Because tuners generate the most noise, the i.f. strip is "put in to bat first".

Starting from the weakest 10μV signal, everything – i.f. strip and tuner – is working at maximum gain. As the signal is increased, the a.g.c. voltage appears and turns down the i.f. gain to compensate. This goes on until about 3mV is arriving at the aerial. The a.g.c. is then applied to the tuner as well, reducing its gain as the signal increases further. The i.f. strip is now said to be working at "minimum gain" and is in fact running at 50dB below its maximum capability – nice and stable, nice and cool.

Optimum Alignment Condition

This is the state usually chosen for optimum alignment of the i.f. strip. Any variable-beta or variable-mu stage in the i.f. strip will have its input capacitance arranged in such a way that the bandwidth narrows as the signal diminishes.

Crossover Point

With transistor tuners you usually get mixer noise below 1mV and crossmodulation (vision buzz) above 10mV. This makes 3mV the decibel midway point at which to set the "crossover". It is also the accepted field strength boundary of primary service areas (70dB on 1μV).

AGC Polarity

A.G.C. is applied negatively to valves and pnp transistors, but positively – towards l.t. – with npn transistors. The forward a.g.c. technique used with transistors gives more control. If npn i.f.s are mixed with pnp tuners an a.g.c. inverting stage is needed unless the tuner is hung upside-down, like a sloth, from the l.t. rail.

Alignmanship!

With a little practice most sets can be completely aligned from the tuner test point, provided they are fault-free. Sometimes it's necessary to take the process stage by stage

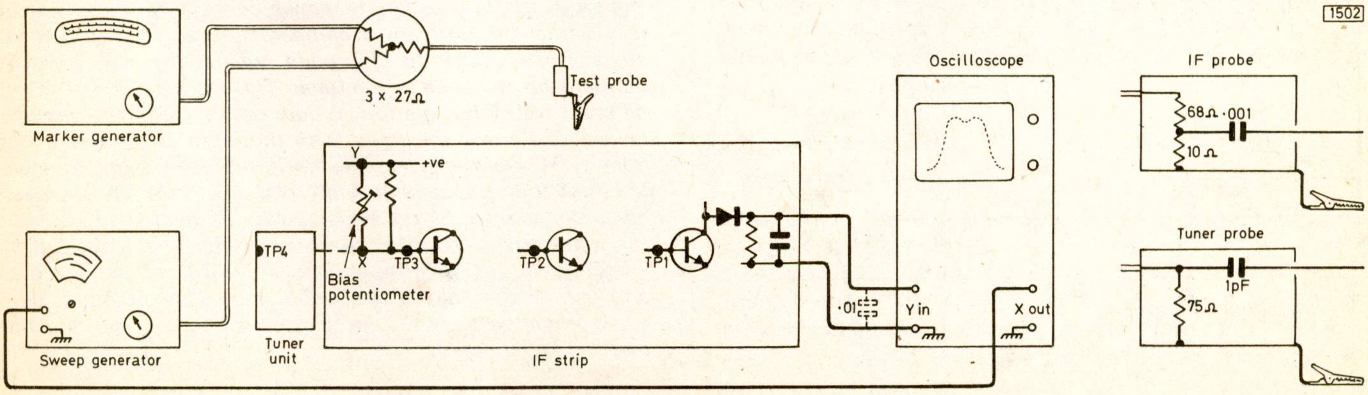


Fig. 1: The basic alignment hook-up.

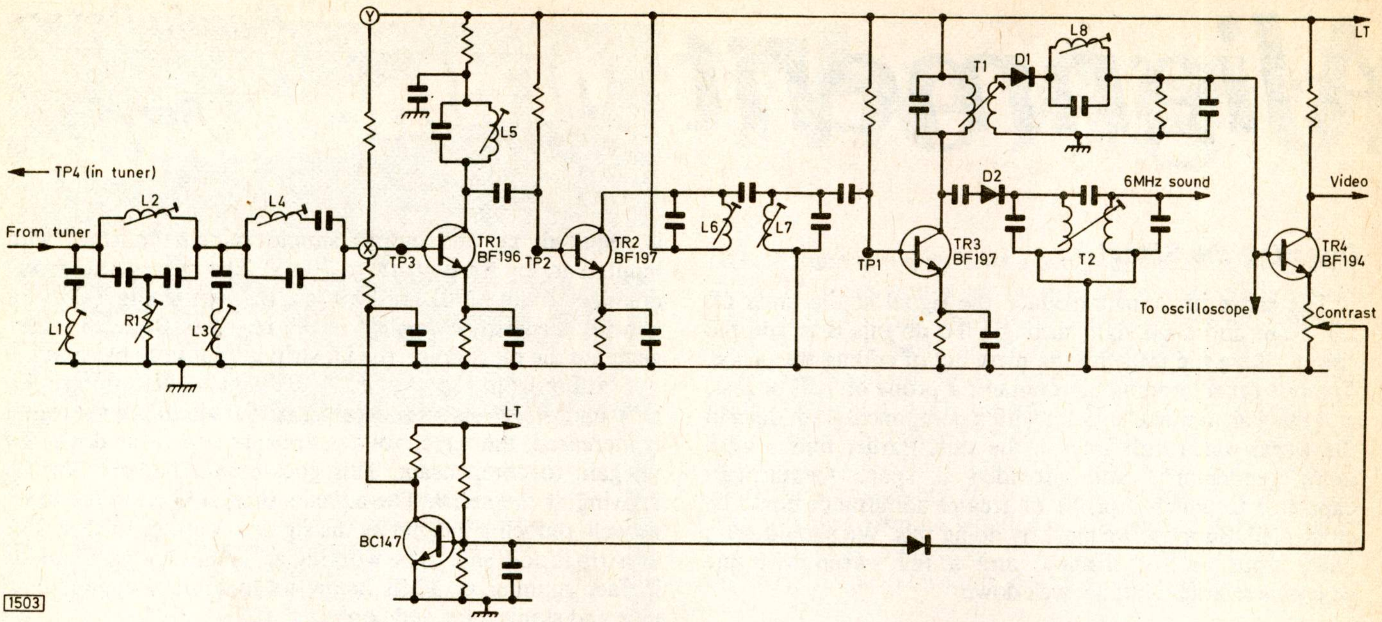


Fig. 2: Typical transistor i.f. strip arrangement, to illustrate how to go about alignment.

as part of a fault-finding procedure, so we'll run through our fictional i.f. strip in this manner as a working example. As previously the display probe is connected across the vision detector all the time (base of Tr4 to chassis, see Fig. 2). The sweep is applied to TP1 (base of Tr3) via the ÷8 probe mentioned last month so as to give a low input impedance. Its chassis earth is important. Use short leads and solder to the cool part of the chassis. The setmaker will have found this for you and either planted an obvious test point there or taken the emitter decoupler to it. Signals entering the set at earlier stages are killed off by grounding TP2 of the previous stage. You will need to turn up the sweep output to around 200mV to get any size of trace.

Detector Alignment

On the alignment diagrams (Fig. 3) we show markers at 39·5MHz and 34·65MHz. The detector transformer T1 is adjusted to balance these around the flat peak. If there is a sound trap (we show one at L8) this should first of all be adjusted for minimum at 33·5MHz as it will affect the 34·65MHz side of the curve. Instead of balancing the markers you could equally well apply a midband marker at 37MHz and trim T1 to peak this at the top of the trace. At this stage the 39·5MHz and 34·65MHz markers should be high on the curve, typically $1\frac{1}{2}$-2dB down from peak. Remember that we try to end up with them both – but especially the 39·5MHz one – at 6dB down from peak, i.e. halfway down the trace. We hope to see them drop progressively stage by stage. They must not be allowed to fall too abruptly at any one stage, as it is extremely difficult to jack them back up again later. If you did succeed in doing that you would play havoc with the group delay of the strip, which is something we have avoided mentioning so far and will return to in a later part.

Bandpass Stage

Having aligned the final i.f. stage, transfer the ÷8 probe to TP2 and move the short which was there to TP3. The

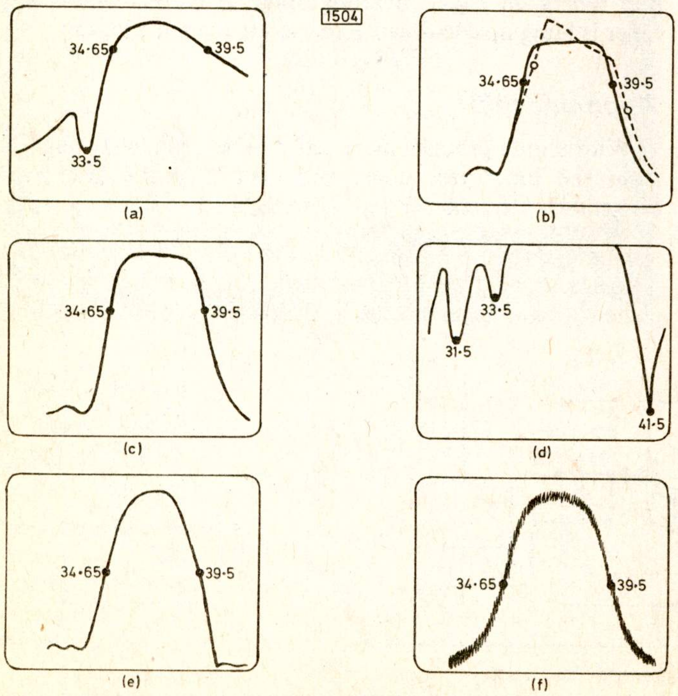


Fig. 3: Response curves obtained at the various stages in aligning the i.f. strip shown in Fig. 2. (a) The last i.f. stage, with the input applied to TP1. Rounded top with the markers high, typically 1-2dB from the peak. (b) The middle i.f. stage, with the input to TP2. One adjustment will rock the top of the curve, the other will move the markers along the trace – as shown in the broken line response curve. When levelled up they settle 1-1·5dB down compared to (a). (c) The first i.f. stage biased back to the point where the a.g.c. would normally be switched to the tuner. This response is not much different to (b), but the top is more rounded and the markers lower. (d) Setting the traps, with the input at the tuner test point (TP4) and the sweep generator turned up high to enable the traps to be set accurately. (e) The tuner/i.f. input bandpass coupling, damped by the traps, rounds off the alignment with the input again at TP4. The vision carrier should be left at −6dB down. (f) With the input still at TP4, remove the bias and reduce the gain of the wobbulator. The maximum gain curve obtained shows a more rounded top, noise, and the markers lower down.

gain of this, the bandpass stage, will be so high that the sweep generator's output will need to be reduced by about 30dB. As you adjust L6 and L7 you will find that one of them will "rock" or move the markers up and down, whilst the other will tilt the top of the trace. With the same objective as before, i.e. of level markers, you should aim to keep the tilts or troughs at the top smaller than the order of ½dB. You will be able to assess the order of bandpass coupling by the height of the markers and the shape of the top of the curve. A trough in the top with high markers indicates overcoupling, while a round top with low markers shows insufficient coupling. A contradiction of these parameters (round top high markers or vice versa) usually means trouble. Sharp corners can also lead to trouble later on, producing ringing on sharp picture edges. But back to the strip.

First IF Stage

Remove the short from TP3 and move the ÷8 probe there. Decouple the tuner output. Don't use a short here as there is often l.t. about. Apply the bias we have already discussed to point X and tune L5 for a similar result to the previous stage. Because of the bias now applied you may have to increase the signal from the sweep generator.

Setting the Traps

Now move to the tuner test point, leaving the bias set but removing the decoupling. Inject the signal at the tuner test point with whatever special probe the mechanics there require. Turn up the sweep generator output so that the top of the trace is well off the top of the screen and the region around the baseline becomes magnified – see Fig. 3(d). Set the traps for the deepest dip. We show three, L1 and L3 are at 31·5MHz and 33·5MHz respectively and are on the left of the trace. You may be able to get them crossed, but the correct way round is for 31·5MHz to be the deeper of the two. 33·5MHz should ideally be 26dB down from the peak, plus whatever suckout there is in any detector trap (L8). With L8 up at the back giving another 10dB the total is 36dB down.

You may be wondering how we get away with the barefaced cheek of maintaining all along that 26dB of sound trapping is ideal and then showing a circuit with 36dB rejection. The explanation is that our circuit features a separate sound take-off circuit T2 with its own detector diode D2. At the point in the circuit where the sound parts company with the vision signal there is only the 26dB attenuation of L3 effective.

The last trap at the front end is the deep one, at 41·5MHz for adjacent sound and Crystal Palace. There are two adjustments. L2 fixes the position while R1 determines the depth. Adjust in that order, repeating if necessary, for the deepest trapping.

Tuner/IF Bandpass

Until you have set these traps there is no point in looking at the top of the trace as the trap skirts will affect its shape. With the traps set, reduce the trace to full scan and do the final tuner/i.f. mating bandpass adjustment (tuner i.f. output coil and L4). This is not as spectacular as the second stage due to the extra damping. Try to achieve the classic response shape, with a nice round cornered top, 39·5MHz at 6dB down from the peak, and 34·65MHz at between 3dB and 8dB down. 35·04MHz (colour subcarrier) should be just down from the top left-hand corner, and 38·25MHz

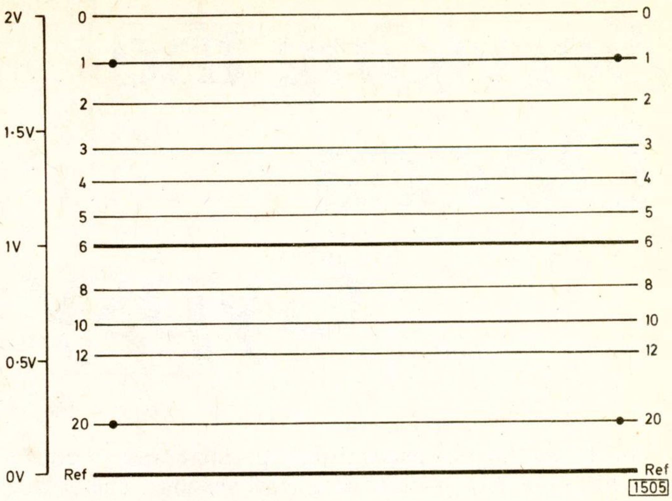


Fig. 4: A dB graticule for display units, plotted against a vertical scale of 0-2V (the typical output of a diode vision detector).

(beginning of the vestigal sideband roll-off) just on the right-hand corner.

Full Gain Trace

Finally remove the bias and look at the full gain trace with a suitably attenuated sweep input. It should be narrower. If it "takes off" you have instability, probably due to the leads from the sweep generator. You can check on this by reverting to off-air operation and looking at the "snow" on the screen. Instability will give rough horizontal lines of noise, or a completely white screen if acute.

RF Hook-up

The pedant should now check the curve obtained with bias against a similar one at u.h.f. drawn from a sweep input injected at the aerial. But having just persuaded you to tackle an i.f. sweep hook-up it is more than we dare suggest that you should try an r.f. one too. Unfortunately the tuner probe is the place where the greatest likelihood of introducing spurious tilts exists. In default of a u.h.f. sweep generator a rough check can be made against a set of known goodness by a comparison of the K ratings of the vertical interval test signal (see *Television* May 1976, pages 379-380).

Damping

In some older valve sets using tightly-coupled i.f. bandpass transformers with separate cores for the primary and secondary windings it may be necessary to damp one winding while adjusting the other. Tune the primary first while damping the secondary with a resistor of say 4·7kΩ, then reverse the procedure. This is a must if normal sweep adjustments produce instability.

Circuit Variations

With valve i.f. strips the trapping and bandpass shaping may be arranged somewhat differently to the transistor example we have given. You won't go far wrong however once you have discovered from the appropriate circuit or manual the frequencies to which the various traps and transformers must be tuned. In many chassis produced in recent years the i.f. stages are wideband, i.e. the only adjustments that can be made are to the bandpass filter network between the tuner and the i.f. strip.