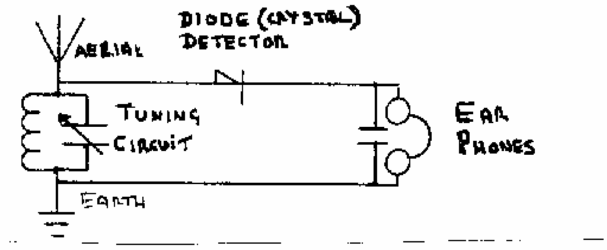
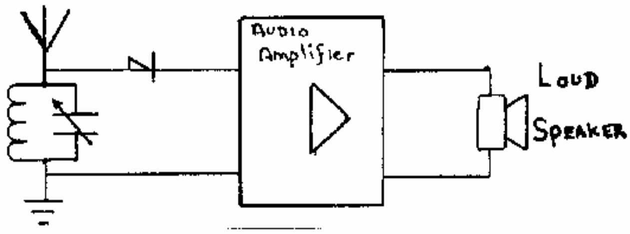
In the beginning there was the Crystal Set...

The wanted frequency is "tuned in" by the variable capacitor in the parallel tuned aerial circuit. The diode detects this minute signal. But the signal can only be heard on the headphones.



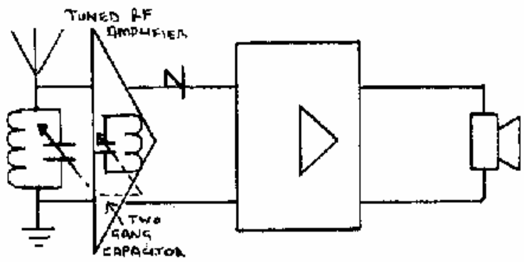
Add an Audio Amplifier -to make it louder

The detected signal is amplified so that it is sufficient to operate a loud speaker.
But this does not improve the sensitivity of the crystal set.



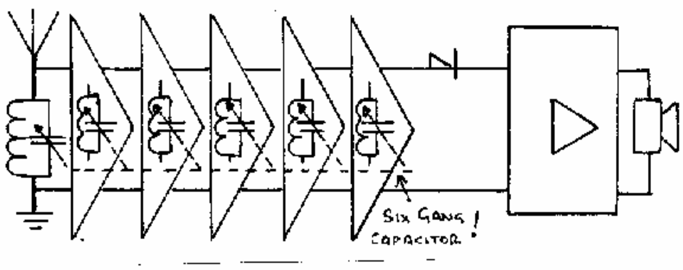
Add a Radio Frequency Amplifier

Both the aerial circuit and Radio Frequency Amplifier are tuned to the wanted frequency. The two tuning capacitors are or the same spindle and are known as Twin Ganged Capacitor.
But even this does not make the receiver very sensitive



Add MORE RF Amplifiers.

The receiver now has several RF amplifiers and is called a TRF(Tuned Radio Frequency) receiver.
IE All amplifier stages are tuned to the frequency of the wanted signal & it is uses a six gang capacitor!
But there can be problems.....



In theory, to further increase the sensitivity of the receiver, more RF amplifiers could be added. But there is a problem: if any of the signal from the output of the last RF stage is able to get back to the aerial circuit, the receiver will oscillate. This is the result of positive feedback arid it means trouble. An oscillating receiver actually becomes a transmitter and will interfere with anyone in the vicinity who is trying to listen to the same frequency.

How can Positive Feedback be prevented :-

EITHER 1) by very careful screening of each RF amplifier stage in the TRF receiver.

OR 2) by changing the frequency of the wanted signal so that the final frequency will not be the same as that arriving at the aerial circuit.

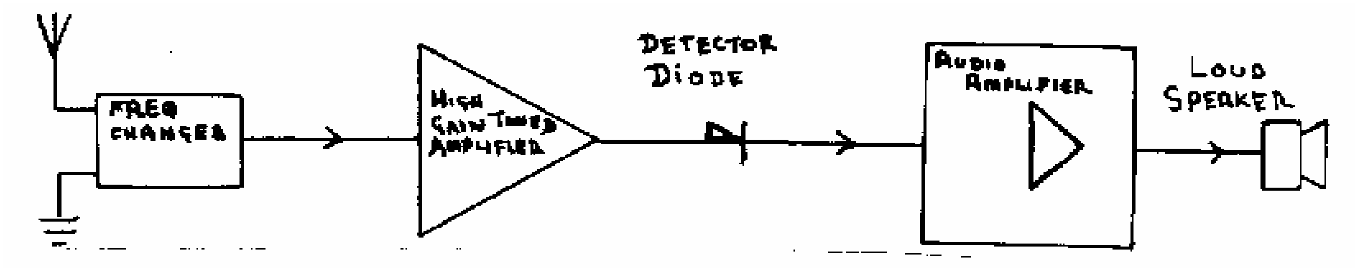
But remember- every RF stage in the receiver has to be tuneable.
Each of their tuned circuits has to be connected to a multi-gang variable capacitor.

A TRF receiver is not a practical solution to the design of a sensitive, reliable, short-wave receiver. The answer has to be both frequency changing & high gain amplification. A high gain, tuneable amplifier is impractical, but all is not lost. It is, however, feasible to design an amplifier on or around a single frequency. Each stage is "fix tuned" and an external ganged tuning capacitor is no longer necessary. This, & screening means that the feedback problems are avoided.

A high gain amplifier - waiting for something to do!

But what is the use of a high amplifier tuned to just one frequency? Does it mean that only one station can be heard? In fact the frequencies most commonly used by these amplifiers are not allocated to any transmitters. This is by design so that the amplifier, as it stands, receives no stations at all. This may seem rather pointless.. read on.

The secret is:*Be Converted*. The frequency of the 'wanted' station is converted to that of the high gain amplifier. It is then detected in the normal way. The resultant audio is then amplified to feed the loudspeaker.



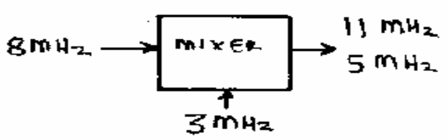
How is the Frequency Changed?

The short answer is - by mixing one frequency with another.

Two frequencies, A and B are fed into the mixer.

As well as the two input frequencies the output will contain:
the SUM of the input frequencies. IE (A + B)
and the DIFFERENCE between the two input frequencies IE (A - B)
Putting in actual figures instead of A and B should make things even clearer.

The output of the mixer will contain both 11 MHz and 5 MHz as well as the original 8 MHz and 3 MHz.



And here is another example:
Take a second look at these figures and then look back at the previous example. A very important principle Is evolving..

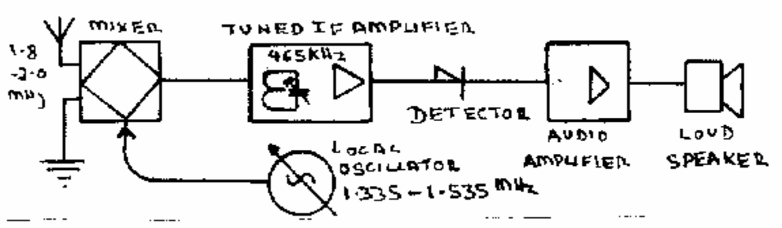
Although the inputs are different one of the outputs (5MHz) is the same in both examples.

What happened?

The 8MHz input went up by 1MHz to 9MHz. The other i/p also changed by 1MHz but there continued to be an output on 5 MHz. This principle of mixing enables one of a range of frequencies to be received and amplified by the high gain fixed frequency amplifier. The precise frequency received depends on the actual frequency injected into the second i/p of the mixer. The amplifier in this example would be designed to operate at 5MHz.

A simple Superhetrodyne Receiver for the 1.8 to 2 MHz band

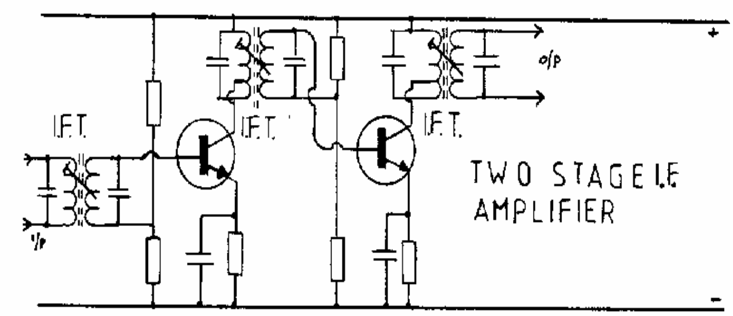
This design is known as a Superhet -(heterodyne is another word for mixing)



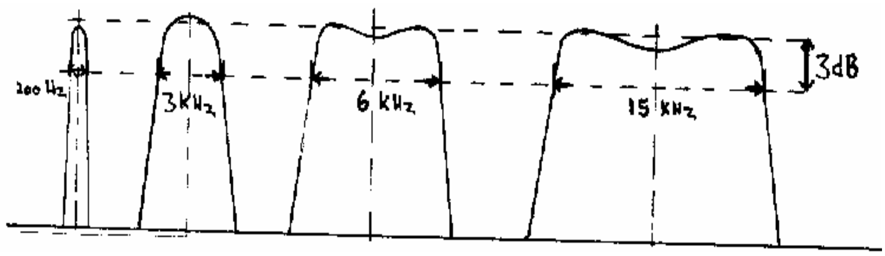
The aerial circuit is connected to one i/p (called local oscillator) is connected to receiver is actually tuned by this oscillator. Superhets for this band would often use an IF amplifier at 465 kHz.
Thus, to tune signals in the range 1.8 to 2.0MHz have to vary from 1.335 to 1.535MHz.

A closer look at the IF Amplifier

This is the heart of the receiver. It usually comprises two or three amplifier stages. Each stage is corrected to the next via an RF transformer designed to pass A just a narrow band of frequencies.



The actual bandwidth should suit the type of signals that are to be received:



Mode	**Bandwidth**
Morse	200Hz
SSB	3KHz
Amateur AM	6kHz
Broadcast AM	15KHz.

Unless the receiver is intended to be very specialised it is best to choose the widest bandwidth. The narrow ones can then be achieved by switching in narrow I.F. filters.

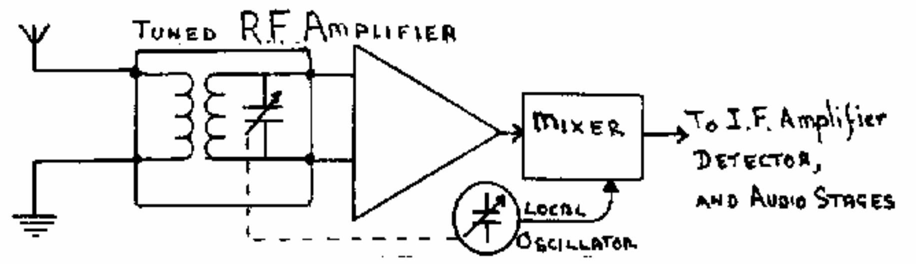
But watch your image!

As seen earlier a mixer has both "sum" and "difference" frequency outputs.
This, unfortunately, means that there are two frequencies that can mix with the local oscillator and give rise to the same **I**ntermediate **F**requency. In other words the receiver will cover both 1.8 to 2.0 MHz and 0.87 to 1.07 KHz at the same time. The latter is a part of the Medium Wave broadcast Band!
There is very little chance of picking up a top band fix station when it has to compete with Radio I or LBC...

How to eliminate your image

Obviously, the image of the wanted frequency, or "Second Channel" as it is sometimes called, has to be overcome. This is done by adding a tuned Radio Frequency amplifier between the aerial and the mixer stage.

The RF stage is tuned by a capacitor "ganged" to the LO tuning capacitor.

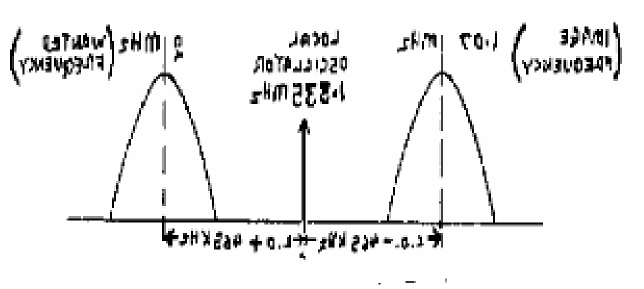


In a superhet there are no feedback problems as a result of using a ganged capacitor as the sections are now operating at different frequencies.

The Radio Frequency Stage

The RF stage, with its parallel tuned circuit, has the typical response curve.

If the LO is tuned to 1.535 MHz the RF circuit will be centred on 2 MHz. The RF tuned circuit will pass the 2 MHz but not the image at 1.07 MHz.

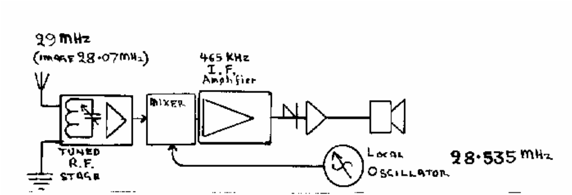


At these frequencies it does not matter that the RF stage does not have a narrow bandwidth as the image is about half of the wanted frequency.
Incidentally, the image is always two times the IF away from the wanted frequency.

All the problems are now solved..

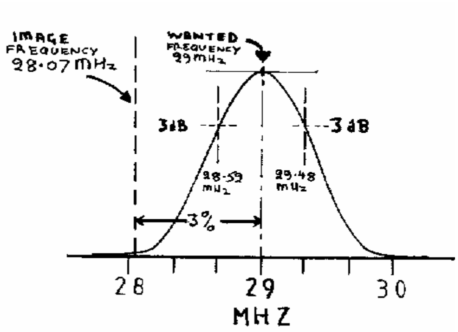
Not quite! The RF stage eliminated the image of the 2 MHz signal successfully.
But how well does the idea work for higher frequencies?
Take, for example, a receiver designed for 29 MHz.

To receive 29MHzthe LO would be on 28.535MHz.The image will be28.07MHz. (This is LO-IF}



The Tuned Circuit in the RF Amplifier.

At these higher frequencies the RF tuned amplifier is less efficient at eliminating the image. At higher frequencies the image actually comes within the pass-band of the tuned cct.At 2MHz the image was approx 1MHz. IE half (50%) of the wanted frequency. However, at 29 MHz the image is 26.07MHz. In other words, the image is just 3% from the wanted frequency.



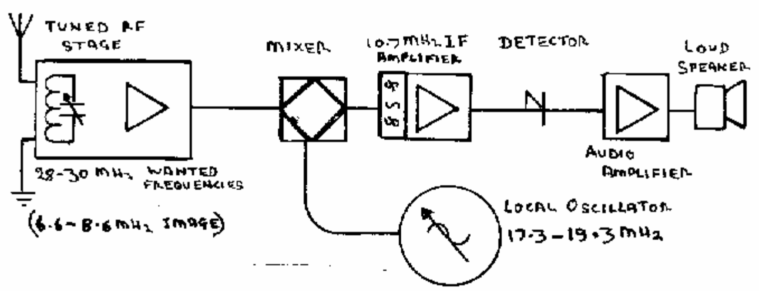
What about the image, again!

At higher frequencies the wanted frequency and its image are so close together that they are not adequately separated by the RF stage.

The answer - ensure a much greater frequency difference between them, remember the difference is always "two times" the IF'. The problem is therefore solved by having a higher Intermediate Frequency. The frequency chosen is usually either 9 or 10.7 MHz.

A 28 to 30 MHz Superhet Receiver using an IF of 10.7 MHz

The image is now21.4MHz from the wanted signal. The RF stage now has no difficulty in picking out the wanted signal and eliminating its image



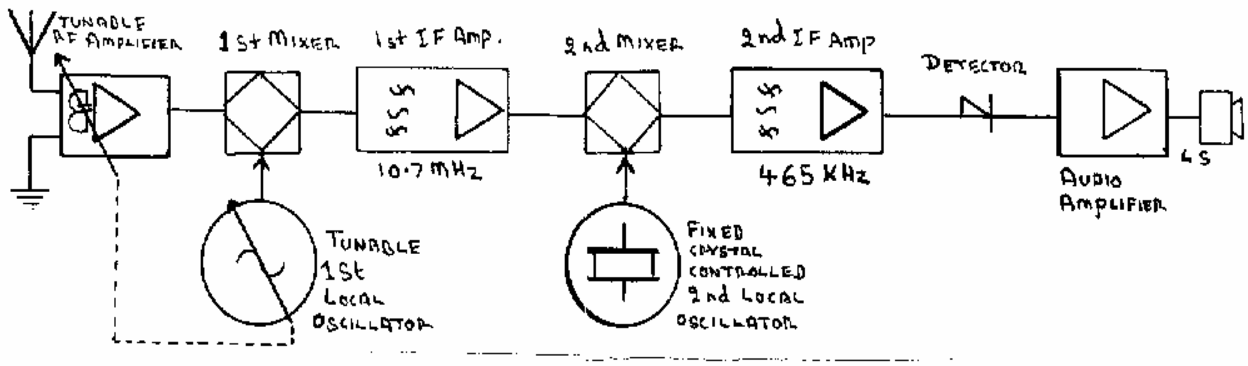
But a high IF is not the answer to everything

The choice of a high intermediate frequency overcomes the image problem but unless an expensive crystal filter is used the receiver is no longer sufficiently selective.
A low IF, with its narrow bandwidth, gives good selectivity.
A high IF, on the other hand, ensures that the image is eliminated,

In other words, each have their advantages.

The solution is obvious - use both high and low IFs

This double-conversion superhet uses a high IF followed by a low IF. This provides very good image rejection and good selectivity over a wide range of frequencies.



The signal is amplified by the tuneable RF amplifier and then mixed with the first local oscillator to produce the first IF 10.7 MHz. The real purpose of the 10.7 MHz IF amplifier is to prevent "image frequency" problems. It is then converted to ~65 kHz by the second mixer. As both IFs are, of course, fixed frequencies the second LO is also fixed. The second LO will be either 10.7 + 0.465 or 10.7 - 0.465 MHz and is a crystal controlled oscillator.

The heart of this more complex receiver is still the high gain 465 kHz amplifier.

Before answering these questions please read the RADIO RECEIVERS chapter in your Radio Amateurs Examination Manual.

You will also find it necessary to dive into the RAE Manual section on Licence Conditions and Receivers for some of the answers.

7a1 What is the function of a detector ?
7a2 What is the purpose of AGC ?
7a3 State an advantage of a TRF receiver.
7a4 Draw the block diagram of a superhet receiver giving a short description of how it works and how it overcomes the problems of a TRF receiver.
7a5 What is the advantage of using a HIGH intermediate frequency ?
7a6 What is the advantage of using a LOW intermediate frequency ?
7a7 A mixer circuit has two inputs- One of these inputs is fed with a 6MHz signal and the other is connected to a 4MHz oscillator.
State at least four frequencies that will be present at the output of the mixer.
7a8 Why is it necessary for the I.F. (Intermediate Frequency) amplifier to have tuned circuits or filters ?
7a9 What is a BFO and why is it necessary when receiving Morse or single-sideband transmissions ?
7a10 To which part of a receiver is the signal strength meter usually connected ?
7all In a superhet receiver why is it an advantage to have some control over the selectivity of the IF amplifier ?
7a12 What is meant by the expression a "ganged capacitor" ?
7a13 What is the difference between a detector and a discriminator ?
7a14 What is the function of a crystal calibrator when fitted to a receiver. (Look in RAE chapter on Test equipment)
7a15 When is it permitted to transmit recorded messages?
7a17 What does the Amateur License stipulate with regards the station receiver.
7a19 There is a segment of an Amateur Band that may not be used in in a certain area of the UK. Which band of frequencies are concerned?
7a20 Describe the operation of a simple *noise limiter* that could be used in a radio receiver.
7a21 Some receivers use two intermediate frequencies… Why?
7a22 What is *distortion?*

Remember that long essay type answers are not necessary

- Just a few sentences in most cases.
- The actual exam is, of course, multiple choice. G4EGQ

