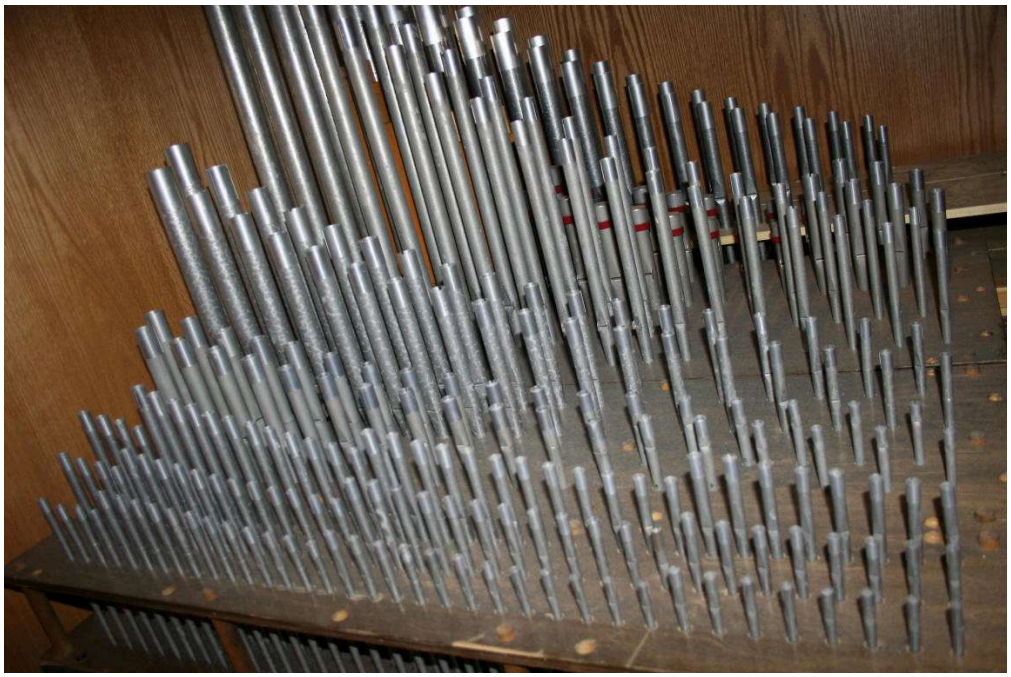
All About Mixtures

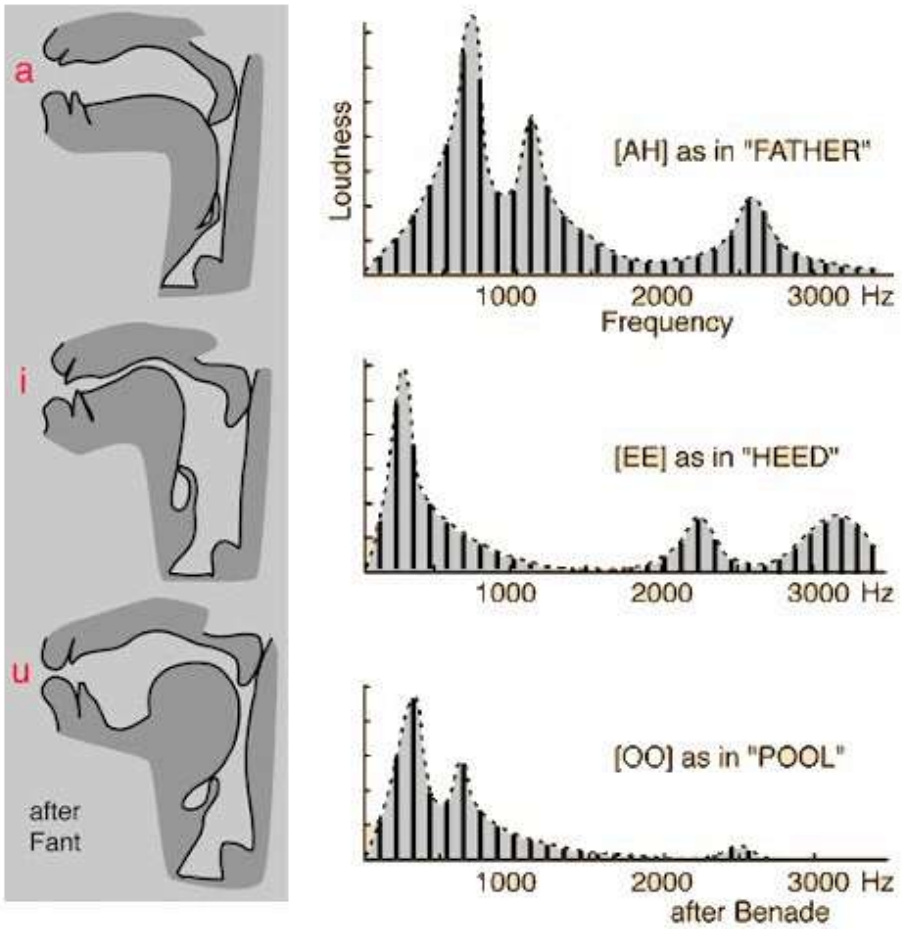


(mixture/mixture2.jpg)

Mixtures, not just about the noise

It is certainly true that adding a mixture to the chorus makes the chorus much brighter and louder. But, depending on how the mixture is designed and voiced, and how it fits with the rest of the chorus, a mixture can make the organ vocal. I don't mean to literally make the organ "speak" words. Instead, by mimicking the formant structure of vowels, mixtures can add a vocal-like color that has powerful musical effects.

Think of it this way: A choir singing a complex canon. If everyone sings on "Mmm", you can't tell the parts apart. But if Sopranos sing "Ee", Altos "Ah", Tenors "Oh", and Basses "Oo", each voice is instantly distinguishable. In the same way, a subtle vocal-like color from the mixtures clarifies the polyphony.



(mixture/vowels.jpg)

The Vocal Organ, all about Vowels

When you speak, your mouth emits a complex mix of sound (vowels and consonants), which are assembled into syllables, words and finally speech. Speech actually is made of two simultaneous tones (or more correctly, partials): a low pitched fundamental (about 250-500 hz) plus a higher pitched partial (900-2,300 hz). There are actually more than two partials, but for what we are doing, we only care about the first two partials (in the drawing, its the left two, lower-pitched partials).

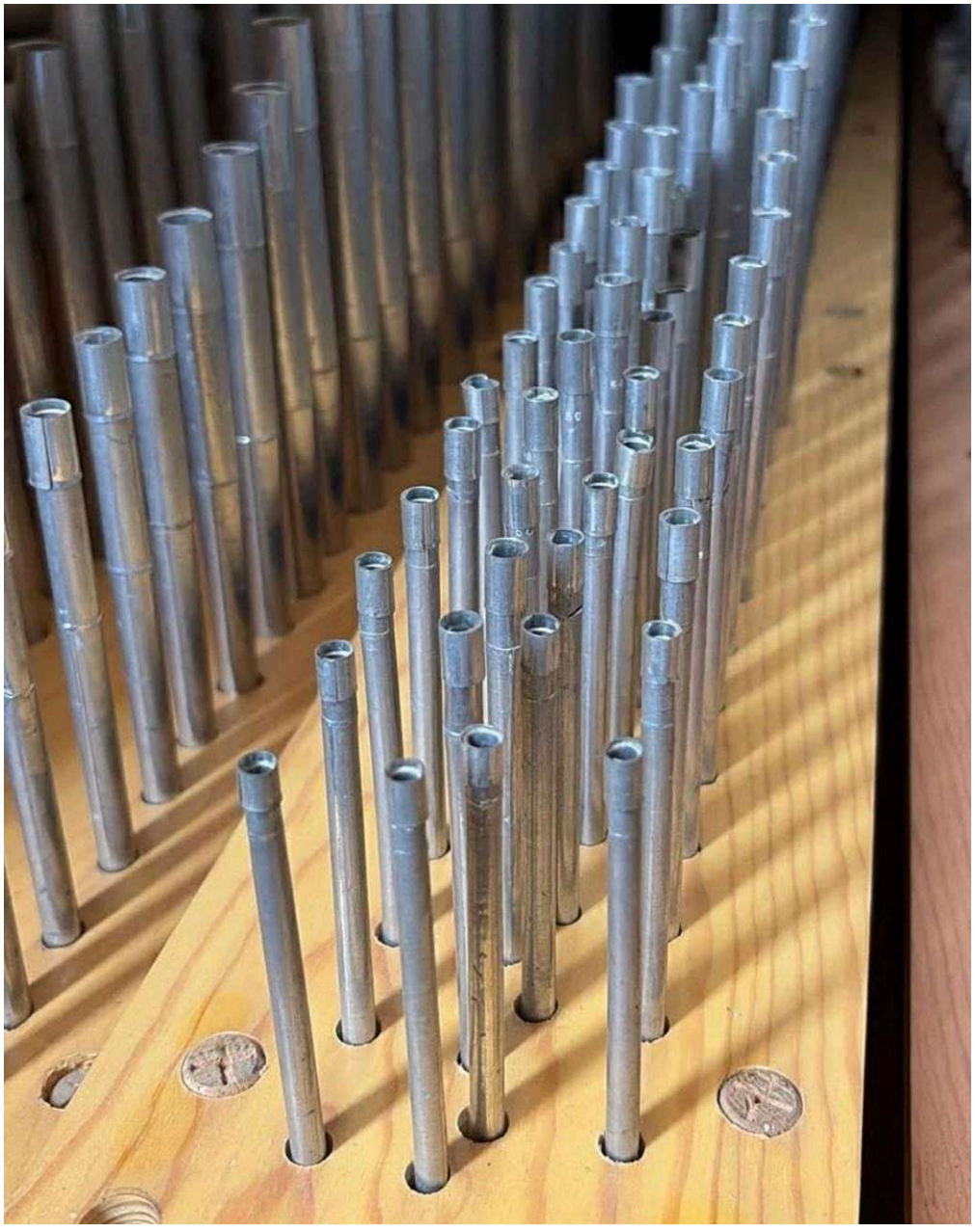
Vowels are distinguished not by fundamental pitch, but by higher pitched partial. The fundamental pitch is the note that you sing. A vowel upper partial is not an exact pitch; rather, it is a band of sound.

Approximate center frequencies of vowel upper partial

- **~2250hz "see"**
- **~1900hz "sit"**
- **~1800hz "bed"**
- **~1600hz "cat"**
- **~1100hz "father"**
- **~ 950hz "saw"**
- **~ 900hz "too"**

You can understand speech, because we all have a sort of "perfect Pitch" ability. Under the right conditions, we hear a sound within certain frequency bands, as a vowel. If you want to hear vowels, try slowly whispering these vowels in this order: "U, O, A, E, I". You can hear the vowel, but you also hear a hiss-sound rise in pitch. It's subtle, but it's all you brain needs translate the pitch to a vowel. Our brains are hard-wired for this.

Speech starts with fundamental sound from your vibrating vocal cords (about 250-500 hz), travelling up your vocal tract (throat and mouth cavity), and out your mouth. Of course the fundamental isn't a sine wave; it includes rich background broadband noise. Your vocal tract (throat, mouth cavity, lips and tongue) is a resonator which acoustically selects, filters and amplifies that sound. By moving our lips, jaw and tongue, we tune the vocal tract, creating the partials of the vowel we want.



(mixture/mixture.jpg)

Gothic Organs

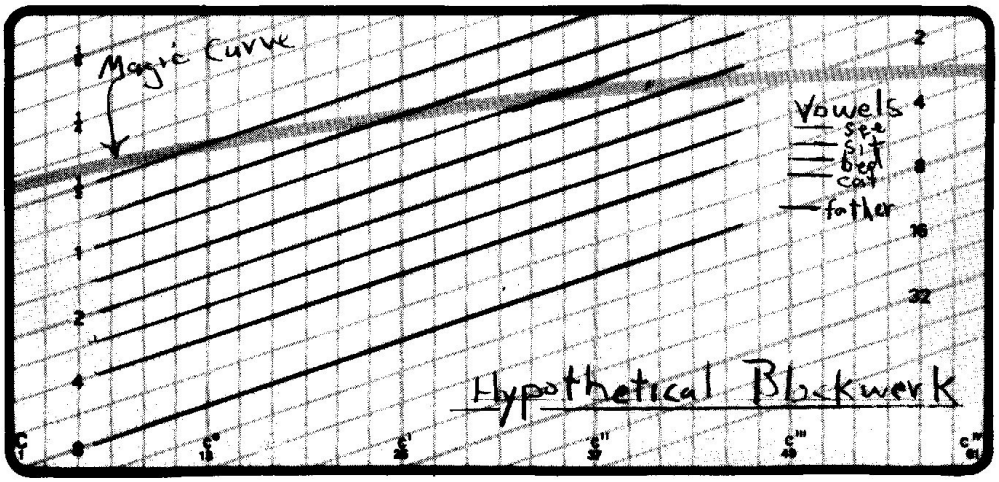
The pipes in a Gothic organ were all principals, with identical voicing and scale. Typically they were a chorus of 8', 4', 3', 2', 1-1/3', 1' and 1/2' ranks. Because there was no stop control, all ranks spoke, all the time. This made a powerful, brilliant sound that filled the room.

But the sound was pure and brilliant chorus. There was no partials, so no vowel colouration. Vowels consist of a lower and upper partial with a gap between them. You need the gaps, to allow the vowel format stand out. But the blockwerk always had all ranks speaking, there were no gaps, so no vowel effect.

With the newly invented stop controls, Renaissance Organs broke apart the Blockwerk. The 8', 4, 2-2/3' & 2' were given their own stop knobs. All the higher pitched ranks were gathered together to form a Hintersatz (blockwerk of upper pipes), simular to a mixture without breaks. The pipes still were all principals, with identical voicing and scale. Despite stop controls, the chorus was essentually a blockwerk decompose, with no mixture breaks, no vowel sounds.

The "vocal" organ effects are most noticable on old Dutch and North/Central German organs. This is because these builders started using breaks in their mixtures, which limited the frequency range of the mixtures. The French and South German Baroque Builders continued to build Renaissance style mixtures, without breaks.

Modern "neo-baroque" organs with low cutups, stringy mixtures, and loud, bright 4', 3' & 2' chorus stops fill the entire spectrum. You end up with a brilliant chorus, but no vowel. With all that brilliance, the vowel format is buried. To hear the vowel, you need space around the Mixture. For a vocal organ the mixture wants to be bold, but fluty (cut it up). And the 4' & 3' should not be assertive.



(mixture/blockwerk-graph.jpg)

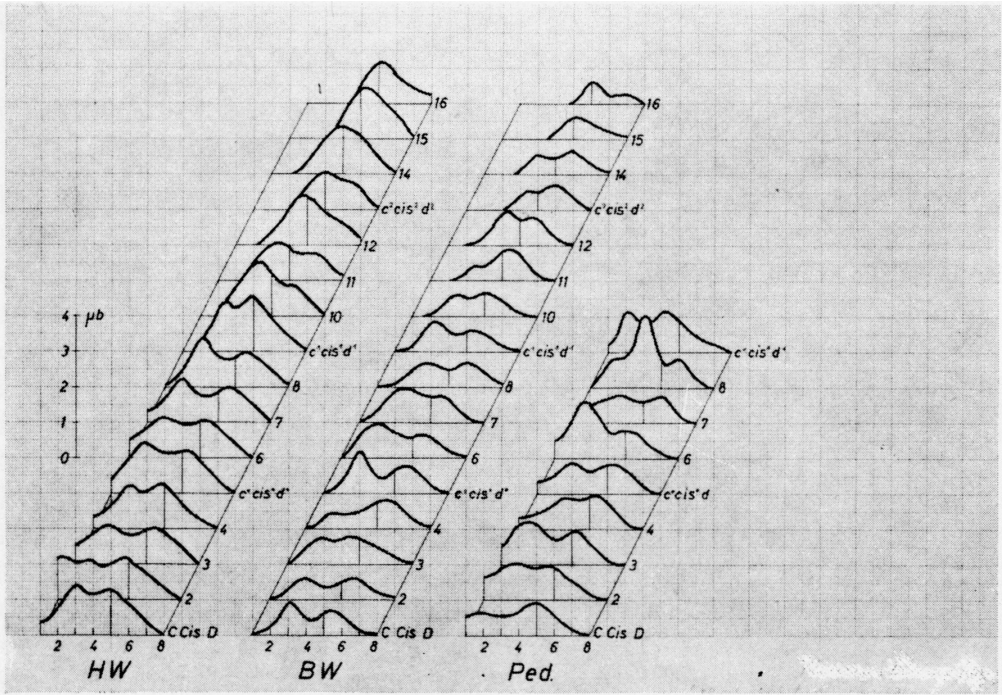
My Mixture Charts

Now, I'm going to pause here and take a minor diversion. Mixture breaks can be difficult to visualize, so I'm going to share the chart (of a hypothetical blockwerk- shown on right) that I graph mixture breaks on. The horizontal scale, from left to right represents the notes of the keyboard, starting a C1 to C61. The vertical scale represents the actual pitch the pipe speaks. The diaginal lines represents each rank of pipes. (Click on the chart to enlarge, blank samples below).

When pipes of a mixture rank get too small, they jump back to a bigger size. That is called a break and is shown on the graph by jumping to a lower diaginal. This graph is a hypothetical blockwerk so there are no breaks.

Mixture Files

- **Blank sample mixture-scales sheet (mixture/sample-mixture-sheet.pdf)**
- **Example of a filled out Mixture-scales sheet (mixture/sample-Gt-mixture.pdf)**
- **Blank mixture breaks sheet - jpg (mixture/mixture-break-graph.jpg)**
- **Blank mixture breaks sheet - pdf (mixture/mixture-break-graph.pdf)**



(mixture/octavebandanalysis - steinkirchen, stade.jpg)

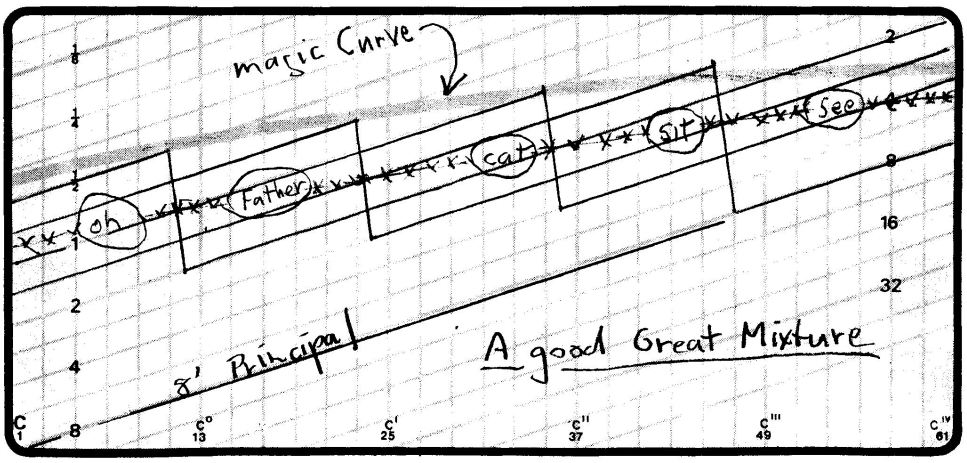
An Organ's Octave Band Analysis

To understand Mixtures, we need to see how they fit into the chorus of an Organ. Fortunately Werner Lottermoser "Orgeln, Kirchen und Akustik" 1983, has made some Octave Band Analysis for us. In the graph at the left of the page, we see his audio spectrums of the famous Schnitger organ in Steinkirchen, Stade.

You'll notice there are about 40 squiggly lines, organized vertically as divisions: HW, BW and Ped. He sampled three adjacent notes simultaniously, to average them out. C, C#, D for the first sample, D#,E, F for the second sample, etc. And each sample is represented by a squiggly line. The squiggly line is the spectrum of those three simultanious notes, summed. So there are 16 spectrums for the Hauptwerk, each consisting of three consecutive notes. He is sampling the Principal chorus, without Trumpet.

I know it sounds confusing, but all that really matters, is that when you look at any spectrums you'll notice there are two humps. The first hump is the 8' stop, and the second hump is the mixture stop. The lower hump acts as a lower partial, the Mixture acts like an upper partial. With a gap between them we've got our vowel. As you go up the keyboard, and up the spectrum lines, we get higher pitched vowels.

To be clear, when laying out his mixtures, Arp Schnitger had no idea about vowels. Vowels are a serendipitous happenstance that some modern builders noticed in some mixtures, and decided to exploit.



(mixture/gt-mixture.jpg)

Baroque Mixtures

The frequency range of vowel's upper partial almost exactly concides with the range of a 2' stop. Not coincidently, it is also the area of maximum sensitivity of human hearing. Sit down at an organ console and put on an 8' and 2' stop. Now, starting at bottom C, slowly play up chromatically to the top. Besides the 2' sound, you may faintly hear a vowel sound, starting at "ooh" at bottom "c" and sliding vowels, to "ee" at top "c". It can be hard to hear; try whispering the vowels to inform your ear as to what you're listening for. Also, try different stops.

Look at the "Good Great Mixture" chart to the upper-left. The mixture starts at "C1" as 1-1/3', 1', 2/3' and 1/2' ranks at the left side of the chart. It breaks about every octave so that at the right side of the page at topnote "c61" it is 8', 4', 2-2/3' and 2'.

Almost all mixtures end up at "c61" as 8', 4', 2-2/3' and 2'. The upper limit is the top of a 2' at "c61", because the pipes get too small to tune. You shouldn't use the 5-1/3' or anything bigger than 8' or you introduce a 16' resultant tone. A higher pitched mixture needs an extra break or breaks, to not exceed the top of a 2', at "c61". You can judge a mixture by noting when the 2-2/3' enters the mixture.

A mixture stop artificially creates a fixed set of reinforced harmonics, independent of which key you play. That is exactly what a formant does: a fixed frequency region that emphasizes certain harmonics of a variable fundamental. If you design a mixture to strongly reinforce harmonics around, say, 500 Hz and 1500 Hz, it will make any note played on it sound somewhat like a particular vowel, relative to that pitch.

Your brain selects the mid-point of the four ranks of a mixture, to determine the vowel sound. On the "Typical Great Mixture" chart, I've drawn the "mid-point vowel line" as a row of "XXXX". I've also written the associated vowels onto that line. So you can see that this great mixture will start at bottom C1 with an "oh", vowel and the tone will gradually transition to "a" at top C61.

Okay, a division with a Mixture can have a vowel colouration, which changes from dark to bright (Oh - ee) as you play up the keyboard. How does that help? You gain two advantages from vowel colour. Please note that the vowel effect can be subtle; if you voice your chorus like a blockwerk, the vowel effect disappears.

1. It Enhances Polyphonic Clarity

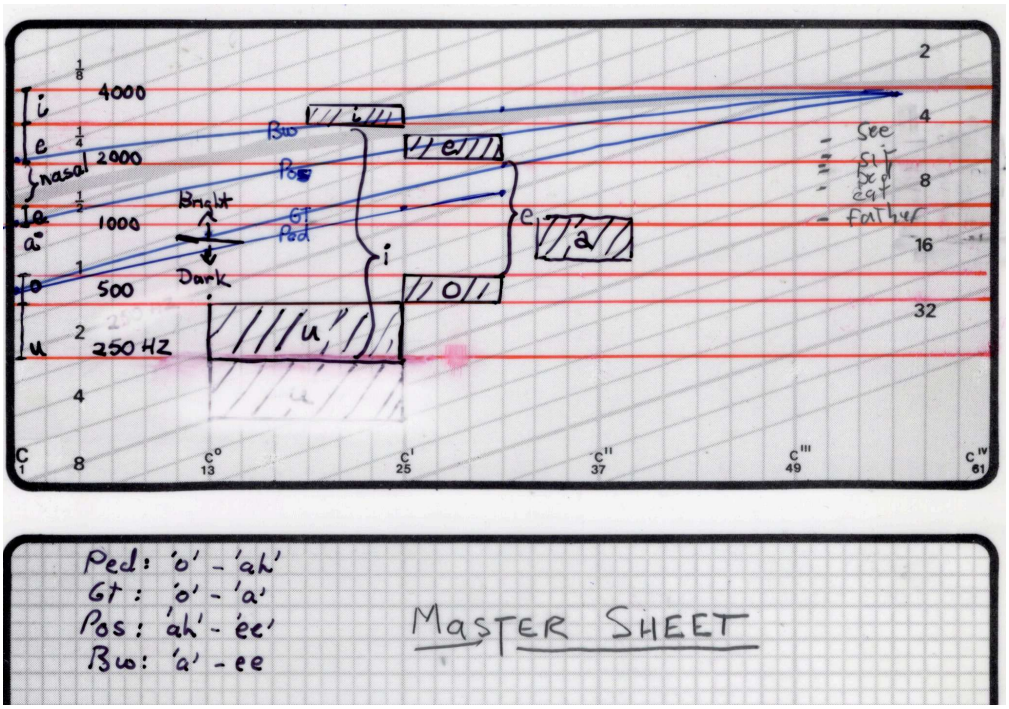
This is the most critical musical function in contrapuntal music (Bach, Buxtehude). When several independent melodies (voices) play at once in the same register, they blur together. A mixture solves this by giving each part of the keyboard a different harmonic fingerprint.

Think of it like this: A choir singing a complex canon. If everyone sings on "Mmm", you can't tell the parts apart. But if Sopranos sing "Ee", Altos "Ah", Tenors "Oh", and Basses "Oo", each voice is instantly distinguishable.

The organ mixture does this pitch-dependently. The left hand playing a low C will have its mixture reinforce harmonics around 1100 Hz (an "Ah" quality). The right hand playing high C on the same mixture stop will have its reinforced harmonics around 2,250 Hz (an "Ee" or hiss-like quality).

In summary: The mixture acts like an automatic intelligibility filter. It vocalizes each pitch range differently, so the listener's ear can effortlessly follow intertwining melodic lines simultaneously. Without this vowel-formant effect, complex fugues become muddy soup.

Because pipes in Blockwerks (and Renaissance organs) have the same scaling and voicing, and they do not break, the organ sounds almost the same as you play up the keyboard from bass to treble. The left hand sounds like it is playing on top of the right hand, muddying the polyphony.



(mixture/vowel-master.jpg)

2. Differentiation of several keyboards

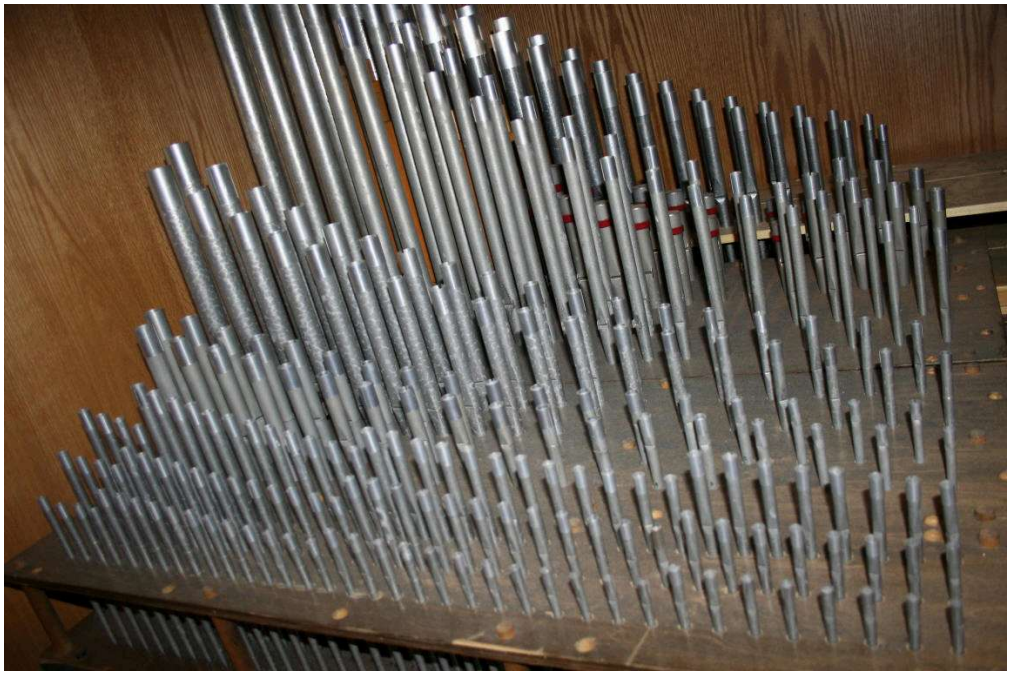
The "magic line" on my mixture sheet is an arbitrary curve, on which the vowels spread out evenly, over the compass of the keyboard. A Great mixture will typically fall below and touch it, Positiv will be on it and Brustwerk be above it. If you draw an unknown mixture onto a blank mixture sheet, the magic line instantly tells you how the mixture compares.

If you look at the "master sheet" to the right, you will see curved lines labeled "Ped, Gt, Pos, Bw". These lines indicate the center points of Mixtures for keyboard of the organ. A different mixture curve means that each keyboard has a different range of vowels.

- **Pedal: C1="oh" -> g32="ah" - (2', 1-1/3', 1')**
- **Great: C1="oh" -> c61="a" - (1-1/3', 1', 2/3', 1/2')**
- **Postv: C1="ah" -> c61="ee" - (2/3', 1/2', 1/3')**
- **Brust: C1="ay" -> c61="ee" - (2/3', 1/2')**

Playing a plenum chord on the Great will have a subtle "ah" sound, Pos an "eh", and Bw an "ee" sound. The vowels give each keyboard a characteristic sound, so a listener immediately recognizes a keyboard change. The Mixtures are the most important stop, to provide differentiation of character between the various keyboards.The mixtures make the Positiv brighter sound than the Great, and the Brustwerk sounding the brightest.

In summary mixtures don't just make an organ louder. They contribute a vowel character to the chorus that 1) helps identify which keyboard you are playing on, and 2) where on the keyboard you are playing. The pitch of the mixture determines which vowel you hear. The voicing and scales of the chorus determine how obvious the vowel is.



(mixture/mixture2.jpg)

Mixtures, working examples

I've got a 3-ring binder of several hundred mixture-break graphs. The variety of design seems endless. I've multiple Mixtures from various vintages and schools of organbuilding. There are some bizarre mixture designs, but the most successful mixtures follow simular design. Fortunately, even if you don't understand about mixtures, it is easy to copy someone who does.

My examples are based upon tradition Northern/Central German Baroque designs, and are simular to the work of good modern builders.

You will notice that by going from Mixture/Scharf/Zimbel, the center of each type of mixture is about an octave higher than the previous, so you will hear the next higher vowel. Also, if you play chromantically up the scale, because of the breaks the "brightness" of the tone rises gradually, spreading out the transition from one vowel to the next.

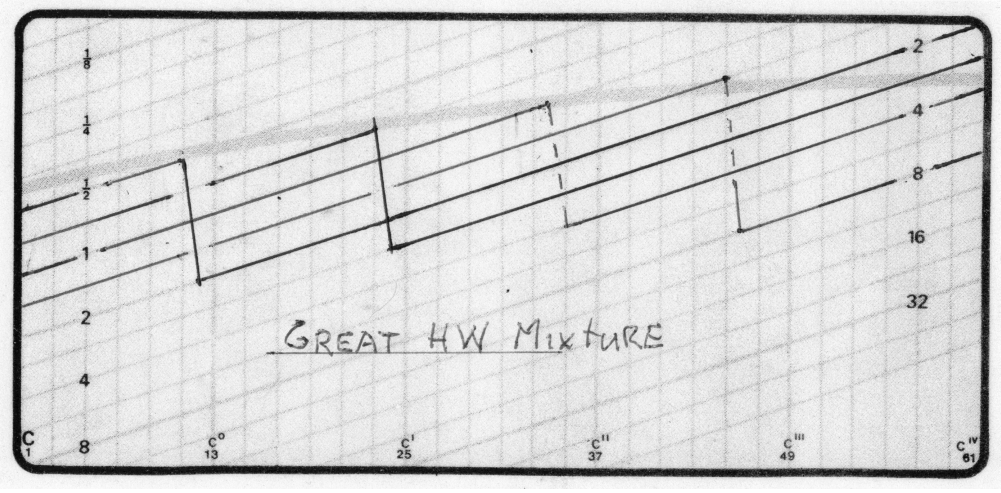
Mixture Loudness

Mixtures should be voiced so that they can be used all the time. If they are so loud that they can only be used at Easter for the last Hymn, they are a waste. I scale and voice the Mixture simular to the 2' Stop. Some people voice the mixture quints softer, or a pipe or two narrower, because they think it makes the mixture "silvery", but I've never found it necessary.

In small rooms, keep it small, use small scales, 17th halving, closed toes and voice gently. Place the mixture at the back of the chest, so it gets blended and diffused by being obscured by the other pipes and distance.

In huge dead buildings it can be difficult to get enough power. You can always get enough power from the bass. Big pipes will get loud enough, if you increase the scale, cutup and wind. But there is only so much you can get out of the small pipes of the Mixture. You can use a treble ascendant scale and cut it up, but you can only increase the scale so much before it gets Cornetty.

Don't try adding more ranks of lower and higher pitch (i.e. 5-6 rank), which would obscure the vowel. A better approach is doubling the ranks: two pipes per rank. Because it is hard to tune more that four ranks at a time, I'd suggest grouping the doubled ranks in a second 3-rank mixture, pitched slightly higher than the main mixture.



(mixture/mixture-great.pdf)

Mixtures, for Great, Hauptwerk

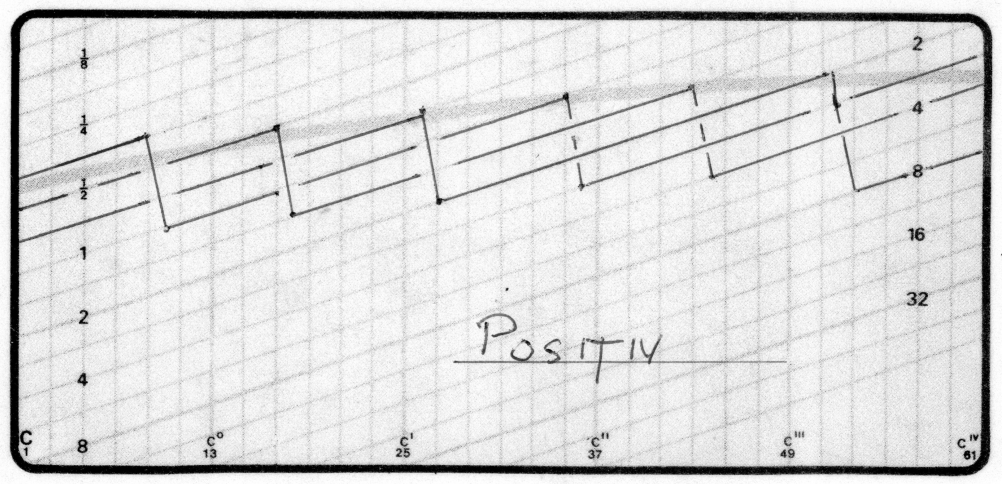
At bottom C1, Great mixtures usually consist of 4 ranks (1-1/3', 1', 2/3', 1/2'). Never use a Tierce rank unless you're using a meantone temperment, because the pure Tierce notes will clash with the tempered ones. Four evenly spaced breaks get you from the bottom of the keyboard to the top.

Since pipes smaller than the top note of a 2' isn't practical, the top ranks of a mixture are usually 8', 4' 2-2/3' and 2'. Don't use a 5-1/3' or you'll create a 16' resultant. Four evenly spaced breaks get you from the bottom of the keyboard to the top.

For a smaller Great, try a three rank mixture. Just eliminate the bottom (1-1/3') rank.

Variants

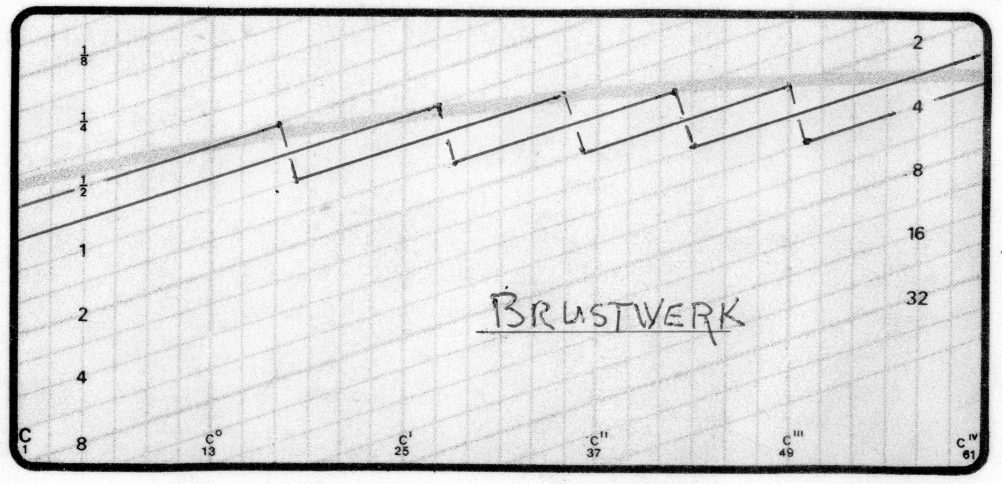
Some people don't like a break between middle "c" and treble "e", because it disturbs the melody. Other people don't like a break in the first 20 notes of the Gt Mixture, as believe the break disturbs the pedal line, when heard thru the Gt-Ped coupler. But these haven't bothered me. You can soften the first and last couple of pipes of every break, to obscure the break.



(mixture/mixture-positiv.pdf)

Mixtures, for Positiv

The center of the Scharf starts about an octave higher in pitch than the Great mixture, but has five breaks, so that it ends up at the same place as the Great at the top of the keyboard. For a small organ, you can use the Scharf for the Great and the Zimbel for the Positiv.



(mixture/mixture-bw.pdf)

Mixtures, for Brustwerk

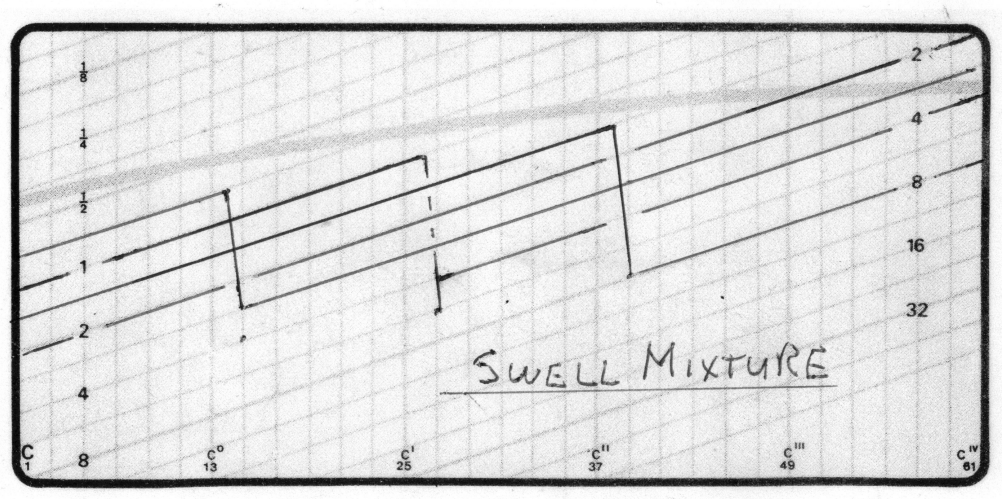
This Zimbel starts at same pitch as the Positiv mixture so it blends better with the BW chorus. But it skips the first break so it's center becomes an octave higher than the Positiv, resulting in a brighter vowel. Like all mixtures, it ends up at the same place as the Great at the top of the

keyboard.

There are different types of Brustwerks. Because the Brustwerk pipework is only a couple of feet from the organist's head, the BW is treated as a miniature division. You could consider it like a box organ, with small scales gently voiced. A single rank Quint 1-1/3' would suffice for mixture. Break the first octave up to 2/3' so it blends better, and break the top octave down to 2-2/3' so it is tuneable.

An alternative is to treat the BW as a Cornet décomposé, which has no use for a Mixture.

In a large organ, the builder may chose to put his Positiv in the BW position. Sometimes it may even get shutters and strings! Then it may get a Zimbel, and hopefully a detached console...



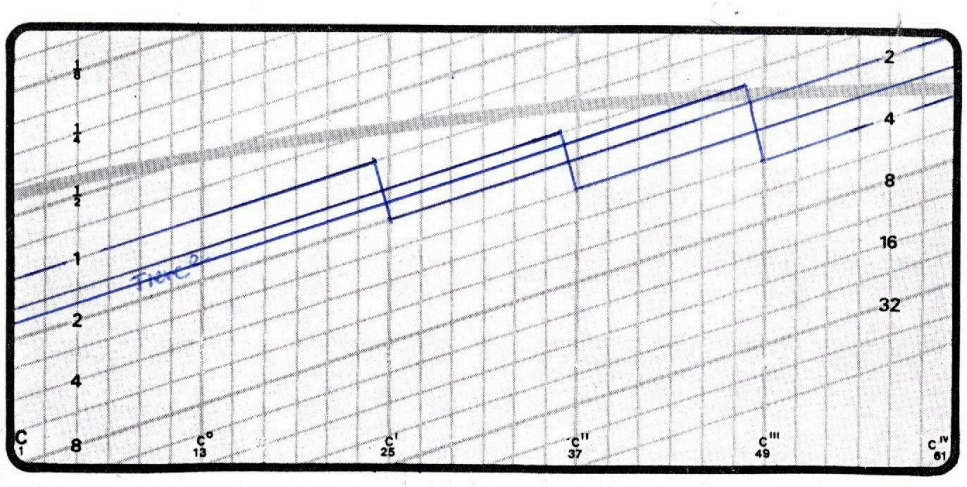
(mixture/mixture-sw.pdf)

Mixtures, Swell

I've already described my approach for Mixtures in Classic organs. But what about romantic Swells? Normally, I treat the Swell as a Positive division with a string and Celeste, plus appropriate Swell reeds.

But in larger organs, especially when rebuilding older romantic organs, I let it stand as a Romantic Swell, without Positiv ambitions. I let it have an 8' chorus (like a Great) with a low pitched Great style mixture. A typical Swell has a Flute chorus, plus strings and reeds. Often

the only principal is an 8' Geigen. A low pitched 2' Mixture will help fill in missing principal chorus.



(mixture/mixture-sw-harmonics.pdf)

Swell Mixtures, Harmonics

An English stop I like to use as a second mixture in a big Swell, is the Harmonics III. I call it "Harmonics" to emphasize that it is not a chorus mixture; it is used only to reinforce the reed chorus (though the English will also call it "Mixture").

It is basically a Tierce, which meshes well with the strong thirds found in reeds. Plus some additional ranks around it, to support it. This is bold, with generous cutups to blend with the reeds.

Shown here is the new Harmonics added by Mander, to their 1998 rebuild of the huge Skinner at Christ Church, Cranbrook, near Detroit, Mi. In the Mander example, all ranks had the same scale, halving on the 18th.

(mixture/cornet.jpg)

Not Mixtures

I love Cornets. But they are not a mixture. They are a solo stop made up of a collection of open flute ranks that are harmonically related.

The Sesquialtera is a two rank cornet-like collection of principals. It is made of 2-2/3' and 1-3/5'. It was popular in the meantone Northern German baroque, but avoided now because of the temperment difficulties of the Tierce. Because of its reedy quality, I don't see it as a substitute for a Mixture.

I've heard Sesquialteras being used like a solo Cornet. But if that's how you want to use it, put in a real Cornet III, it works so much better...

There are mixtures with tierce ranks, originally intended for Meantone organs with pure thirds. I don't recommend using tierce ranks in equally tempered chorus mixtures. It's tuning clashes with tempered thirds, muddying the chorus. Tierces should only be used in solo combinations (like Cornets), so they don't clash with the temperment.

Sample Mixtures

- **Great/Hauptwerk Mixture (mixture/mixture-great.pdf)**
- **Positiv Scharf (mixture/mixture-positiv.pdf)**
- **BW Zimbel (mixture/mixture-bw.pdf)**
- **Romantic Swell Mixture (mixture/mixture-sw.pdf)**
- **Swell Harmonics mixture (mixture/mixture-sw-harmonics.pdf)**

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