

Exploring a pipe organ with CATO

Answers and Commentary for Teachers

1 High & Low

This topic is mainly about the length of pipes and the different pitches of the notes they produce. In principle, each note on the keyboard needs a separate pipe. The critical measurement determining pitch is the distance between the mouth and the top of the pipe.

♪ *The picture shows just 6 pipes. How many should there be altogether for all the keys?*
Most organs have 5 octaves = 61 notes.

♪ *What is the main difference in the sound given by these six pipes?*
As the pipe gets smaller, the pitch becomes higher. For these six pipes the pitch rises by one octave from each to the next. This is because the length halves from each to next.

♪ *Why do we say that the notes from these pipes are 'an octave apart'?*
Musicians always count the first and last note when describing an interval between two notes. Thus the interval of 8 notes is called an octave.

An octopus has 8 tentacles (legs, toes or fingers)
The only connection with an octave is the number 8!

Another 8 connection: octagon
Left: The octagonal lantern at Ely Cathedral
Right: An octagonal table top.

♪ *Try humming a note and then another, an octave higher or lower.*
The octave is the simplest of musical intervals and getting children to hear this is an important aural skill. For younger children it is less easy than it seems, but by demonstration they can be taught to recognise the octave. The pitch of the first note is critical in determining how easy the second note is to find. It may be easily demonstrated with any musical instrument available.

♪ *Write down the lengths of each of the other pipes in feet.*
In feet: 4, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$

♪ *If 1 foot = 30 centimetres, write down the lengths of the pipes in centimetres.*
In centimetres: 120, 60, 30, 15, 7.5

♪ *How many ranks of pipes can you see in this photo?*
5 ranks are visible, not counting the larger display pipes to the right.
Some of the ranks are arranged in double rows. The external colour of the pipes is the most distinguishing feature in this photo.

♪ *How many octaves higher does a 4 ft rank sound?*
4 ft: One octave higher

♪ *How many octaves higher does a 2 ft rank sound?*
2 ft: Two octaves higher

♪ *Some ranks start with a 16 ft pipe. How does this type of rank sound?*
16 ft: One octave lower

♪ *How many combinations can you make from 8ft, 4ft and 2ft stops?*

Organists generally use 8, 8 + 4, 8 + 2, 8 + 4 + 2; i.e. Four combinations
4 + 2 is also possible but rarely used because a foundation tone of 8 ft is normally required. However by playing an octave lower, 4 ft can serve as a foundation.
Haydn wrote a set of pieces for a musical clock (with pipes) which can sound charming on a single 4ft flute tone.

♪ *What is the length of the bottom note for the Twelfth?*

Twelfth bottom note: 2 2/3 feet

♪ *In the photo, find a stop which sounds an octave below the Twelfth.*

Quint

♪ *What is the length of its bottom note pipe?*

bottom note: 5 1/3 feet

These lengths might at first seem rather strange, but the arithmetic is really rather simple:

$2 \frac{2}{3} = 8 / 3$ (3rd harmonic of 8ft tone)

$5 \frac{1}{3} = 16 / 3$ (3rd harmonic of 16th tone)

The photo shows the interior of one of the divisions of the Wanamaker organ in Macey's store in Philadelphia, USA. The original owner of the store, a John Wanamaker, bought the large organ originally built for the St Louis Exposition. He installed it in the 7 storey atrium of his department store, but for several years kept on adding further pipes and divisions to make it louder. Recitals are still regularly held and broadcast on the radio and Internet.

♪ *Can you think of a reason for the smallest pipes being placed in the middle?*

This arrangement provides convenient access for maintenance purposes. From time to time each individual pipe needs to be tuned by adjusting the metal sleeve on the top of the pipe. Imagine doing this for 28,000 pipes!

♪ *What effect would the man in the photo hear if you played each note, one at a time, starting from the lowest note and finishing at the top?*

In the CATO workshop children listen at close range to a chromatic scale (black and white notes in succession) played from the bottom note to the top. The stereophonic effect of pipes sounding alternately from left and right of the display case is distinctly audible. This alternate symmetrical arrangement of the pipes is almost universally employed, so the man in the picture would hear the same alternating effect as did the children. For tuning purposes, the tuning assistant at the keyboard would not play a chromatic scale, but would play a descending scale on every other note, first on one side and then on the other. This helps the tuner to avoid getting a stiff neck!

2 Organ Tones

This topic prompts thinking about the range of the range of musical moods and emotions which can be invoked by organ music and matching these with the variety of events and occasions for which the organ can perform. It is a challenge to express musical sounds and abstract ideas in words.

♪ *Choose some of the above words to describe the sort of musical sounds you would expect to hear at the following events:*

Carol singing: Cheerful, exciting, loud....?

Wedding: Cheerful, exciting, loud, majestic, brilliant, grand....?

Memorial service: Quiet, mellow, soothing, soft, mysterious....? Maybe joyful and loud?

Coronation: Grand, majestic, exciting, loud....?

Opinions will vary and this activity can be good for stimulating discussion.

The picture shows the inside of an organ which is not normally visible. Points for attention:

- Orderly arrangement of pipes from large to small in rows.
- All the pipes have different lengths.
- Both wood and metal are used for making pipes.
- The variety of shapes and materials gives a variety of different tone.

♪ *In the photo, how many ranks of pipes are made of wood and how many of metal?*

Metal ranks: 7

Wooden ranks: 2

♪ *What types of metal are used for making organ pipes?*

Lead and tin are the main metals used in organ pipes. Pure tin is sometimes used for the highly polished display pipes at the front of the organ case. Tin is a hard metal and the tone from tin pipes tends to be bright. However this metal is expensive and an alloy or mixture of tin with lead is most commonly used. Very old organs sometimes contain pipes of pure lead. The tone is less bright for such pipes and the softness of the metal makes the pipes gradually deform due to their own weight. Large pipes are often made out of zinc, a dull-grey metal but which is cheaper than both lead and tin.

Lead has been used for plumbing and roofing for centuries.

Tin cans are typically made of steel plate coated with tin.

Zinc is often used as a surface layer to prevent corrosion as in this example of aluminium roof cladding.

♪ *Describe the different shapes of pipe in the photo.*

Cylindrical metal pipes; conical metal pipes; rectangular wooden pipes.

An important aspect of the art of organ building is the skill of combining the variables of material, shape, air pressure, air velocity and more.

The picture shows a demonstration set of pipes of different designs.

Left to right: Gedeckt, Clear flute, Viola, Principal (50% tin), Principal (30%) tin, Doppelflute, Vox humana, Trumpet, Oboe, Gemshorn

Pipes known as 'Reeds' contain a thin strip of brass which vibrates when air is blown through the pipe, in a similar manner to the vibrating reeds in a mouth organ or harmonica. Pipes without a reed are known as 'Flue' pipes.

♪ *Try to match a pipe number in the photo to each of the following descriptions:*

Open diapason: 5, 6

Viola: 3

Flute: 1, 2, 4, 7

Trumpet: 9

♪ *Work out how many combinations you can make from the four stops shown.*

Organists generally use 8, 8 + 4, 8 + 2, 8 + 4 + 2; i.e. Four combinations
4 + 2 is also possible but rarely used because a foundation tone of 8 ft is normally required. However by playing an octave lower, 4 ft can serve as a foundation.

♪ *What combination would you use for accompanying lots of people singing a hymn?*

Use all four stops for a bright chorus sound.

3 Pipe Families

Although there are many different shapes of pipes made from a variety of materials, there are five families, whereby each family has a characteristic tone.

Mixture ranks are never used on their own. They are the highest pitch pipes in the organ and are usually added above a chorus of foundation stops.

To understand an organ it is important to have a clear idea of the different sections (divisions) of the organ which have distinctive functions.

An organist needs to know the names of the stops and the type of sound each produces. It helps to recognise the families of pipes in each division.

♪ *Arrange the following stop names into the five families. The colours should help you.*

Diapasons: Double diapason, Fifteenth, Open Diapason, Principal, Tierce, Twelfth
Flutes: Bourdon, Claribel, Harmonic Flute, Hohl Flute, Nazard, Rohr Flute, Suabe Flute
Reeds: Bassoon, Clarinet, Clarion, Cornopean, Cremona, Oboe, Posaune, Trumpet, Trombone, Tuba, Vox Humana
Strings: Gamba, Salicional, Violone, Vox Celeste
Mixtures: Cymbale, Sesquialtera, Sharp Mixture

In a mixture rank there are several pipes for each note, in this case three pipes. The numbers describe the number of notes higher than normal pitch: 15 notes = two octaves higher; 19 = two octaves+fifth higher; 22 = three octaves higher; 26 = three octaves+fifth higher.

♪ *Try to spot the five families of pipes in the list of stops for this organ below.*

Diapasons: Double Diapason, Open Diapason, Principal, Twelfth, Fifteenth, Sub Bass, Octave Diapason
Reeds: Trumpet, Tuba Bassoon, Horn, Oboe, Trombone, Contra Fagotto
Flutes: Claribel flute, Nason Flute, Bourdon, Rohr Gedeckt, Piccolo, Bass Flute
Strings: Viol de Gamba, Voix Celeste, Violone
Mixtures: Mixture

There are many more names found on organs than the common ones shown here.

Notice how many names are borrowed from other instruments, both wind and strings. Some of these borrowed names emerged in the 19th Century when organ builders began experimenting to make pipes which imitated the sound of orchestral instruments. At this time when mainly wealthy people had access to orchestral concerts, organs were used in concerts to play the classical orchestral music of the day.

♪ *How many instrument names can you spot in the list of organ stops?*

Flute, Trumpet, Tuba, Viol de Gamba, Piccolo, Bassoon, Horn, Oboe, Violone, Trombone

♪ *Make a list of the REED stops with orchestral names.*

Trumpet, Tuba, Bassoon, Horn, Oboe, Trombone

♪ *Make a list of the FLUTE stops with orchestral names.*

Flute, Piccolo

4 Loud & Soft

The 'feel' and function of an organ keyboard is fundamentally different from that of a piano.

Organ:

1. On a mechanical action organ, the keys are connected to the individual pipes by a system of levers which sometimes demand strong downward pressure.
2. A pipe sounds continuously while a key is depressed. There is no control over loudness.
3. The release of the key requires more precise control than with a piano.
4. There is no equivalent of a piano's sustaining pedal, so organists learn how to play a series of notes 'legato' (joined up) without any gaps between the sounds.

Piano:

1. The key is connected to a hammer which hits a string momentarily.
2. The sound gradually dies away after striking a note.
3. The downward force on the key determines the loudness of the sound.
4. The sustaining pedal is used to achieve 'legato' playing.

♪ The stops shown here have different loudness, but what is the other difference in the sounds that they make?

The stops have different loudness, but the tone of the sound is also different.

Reeds stops are generally louder than flue stops. As with flues, stops have different loudness, but the tone of the sound is also different.

Organs vary in their mechanical aids or 'accessories' for making the selection of stops easier. In these examples the buttons activate electro-magnets which push the stops in or out in combinations which have been pre-set. Combination pistons for selecting stops are indispensable in large organs such as that in Liverpool Cathedral.

♪ Explain how the organist would choose stops for each manual to do this.

Each manual might have a different combination of stops, differing in loudness and tone. A quick change of manual allows sudden changes of loudness.

♪ What useful effect can the organist create with one hand on one manual and the other hand on a different manual?

A common effect is to play a tune on one manual with a loud stop against an accompaniment on the second manual.

The use of the Swell pedal is the main means by which an organist can produce gradual changes of loudness. As the box is altered, the tone also varies: the bright tones are quietened more than low pitched tones.

♪ In music, the terms crescendo and diminuendo are used to describe changes of loudness. Explain how the Swell pedal is used to make a crescendo.

Push the pedal forward with the toe.

♪ How would you use the Swell pedal to make a diminuendo?

Push down on the pedal with the heel.

♪ What is the musical word for playing music very softly?

Pianissimo = very soft

5 Hands & Feet

This is a typical 3-manuals and pedals console. If it is detached from the organ, it is linked to the organ by electric cables. If it is integrated into the organ case, the keys, pedals and stops are likely to be connected to the organ mechanism through a complex system of levers.

In a three-manual organ, the Great is always the middle manual. In a two-manual organ the Great is the lower manual. The stops for the Great are usually on the right hand side of the console.

The Swell manual is always above the Great manual. The stops for the Swell are usually on the left hand side of the console.

♪ *Add captions and arrows to show the manual and the stops for the Choir Organ.*

The manual for the Choir Organ is the lowest one. The stops are on the right hand side next to those for the Great.

♪ *Think of some reasons why it is useful to have more than one manual.*

Two or more manuals allow a:

- quick change of tone or loudness.
- contrast of tone between the manuals
- tune to be played with a different tone from an accompaniment

♪ *Give some reasons why it is useful to have several different stops for each manual.*

The selection of different stops provides a variety of tone and loudness.

♪ *Explain why the organist might want to couple two manuals together.*

When manuals are coupled, the pipes for both manuals may be played together making an even louder sound than one manual on its own.

♪ *What sort of tone do the pedals give to the sound of the organ?*

The stops for the pedals generally have a low bass tone giving a throbbing foundation to the sound of the manuals.

The 'Great to Pedal' is an example of a coupler stop which does not produce any sound on its own but facilitates the playing of the lower half of the manual with the feet.

♪ *What is the musical word for making the music gradually **louder**?*

Gradually louder: crescendo

♪ *What is the musical word for making the music gradually **softer**?*

Gradually softer: diminuendo

♪ *Make a list of at least **four things** which your hands have to control at the console.*

Hands: press keys, pull stops, press combination thumb pistons, turn pages

♪ *Make another list of at least **three things** which your feet have to do at the console.*

Feet: press pedals, operate Swell pedal, press combination toe pistons

Playing an organ requires multi-tasking.

6 Organ Design

The diagram shows the structure of an organ with a console which is detached from the main working parts. All the keys and stops are linked by electric cables which activate electromagnets to control the supply of air to the pipes. On a mechanical action organ, the keys would be connected directly to the individual pipes by a system of levers.

♪ *What happens to the sound of the Swell organ as the Swell Box is opened or closed?*
The loudness varies as the Swell box is opened or closed.

♪ *Describe the main differences in the sounds made by the Great, Swell and Pedal organs.*

The shutters on the Swell box work like slotted blinds. In this example, each shutter swivels about a vertical axis. In some organs the axes are horizontal. The Swell box is designed to allow the loudness of the Swell pipes to be varied in a smooth continuous way. The Great pipework is not enclosed at all, so there is no control of the loudness of a rank of pipes.

The photo shows the organ in the Church of St Peter Mancroft, Norwich.

♪ *The large towers contain the pipes for which part of the organ?*
The towers contain the large pipes for the pedal division.

♪ *Look carefully at the picture to see if it is true that the patterns on the right hand side are a mirror reflection of those on the left.*

No two pipes in a pattern have the same length. The pipes on one side of centre are each slightly longer or shorter than the corresponding pipes on the other side.

♪ *Look at the front rank of pipes and decide whether the odd numbered pipes are on the right or left of the pattern.*

♪ *Choose another rank and work out where the odd and even numbers are.*

The centre front rank of pipes has odd numbers on the left and even numbers on the right. It is opposite for the rank immediately behind with the tallest pipe in the middle.

Many decorative painted patterns on pipes take inspiration from feathers, flowers and foliage.

Organ of the Church of St Barbara, Kutna Hora, Czech Republic

♪ *Try to name all the instruments played by the golden angels on top of the ornate organ in the picture below.*

Harp, cello, flute, horns, trumpets, oboe, timpani (drums)