

SETTING UP AN OAS INSTRUMENT FOR OPTIMUM SOUND QUALITY

PART 3 – REVERBERATION CONTROLS

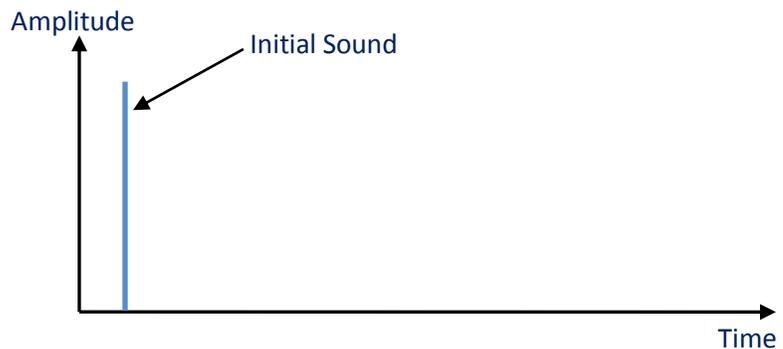
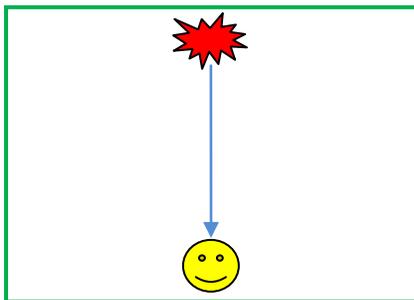
Basic Principles

Reverberation is the name given to an echo like effect that occurs when sound is reflected off the walls, floor and ceilings of rooms and buildings. In an echo however the reflections are well spaced out in time so we hear these as distinct copies of the original sound, whereas in reverberation the reflections are much close together and are perceived as a continuous decaying of the sound. The length and intensity of the reverberation depends on the size of the room, the texture of the reflected surfaces and the presence of any sound absorbing material in the room. Smooth, hard surfaces like plaster, tiles, brickwork and windows are very reflective whereas soft furnishings like curtains, carpets, upholstery and people are very absorbent. So a large building like a church will be highly reverberant whilst a small room like a domestic living room will exhibit very little reverberation. Electronic reverberation units are designed to emulate the way in which reverberation is initiated, builds up and decays so an understanding of this process is an essential requirement to configuring these units successfully.

The reverberation process can be divided into three time related stages. To see the effect of these we shall consider what happens in a room when a sound is generated and heard by a listener. It's also useful to plot the effect on a time graph. This enables us to identify the various parameters associated with the effect, many of which can be specified by the controls on the OAS reverberation menus. These are shown in bold type in the following discussion.

1) *The Initial Sound*

This is the beginning of the sound. Typically we become aware of reverberation when the source is a short burst of sound like a handclap or a shout or when the sound ceases, but reverberation is always present as long as sound is being produced. After the initial sound occurs, sound waves travel out in all directions from this source to reach our ears directly. For simplicity this transmission is indicated on the room diagram as a straight line but in reality sound waves are propagated as disturbances in the air rather like ripples in a pond when a stone has been thrown in.

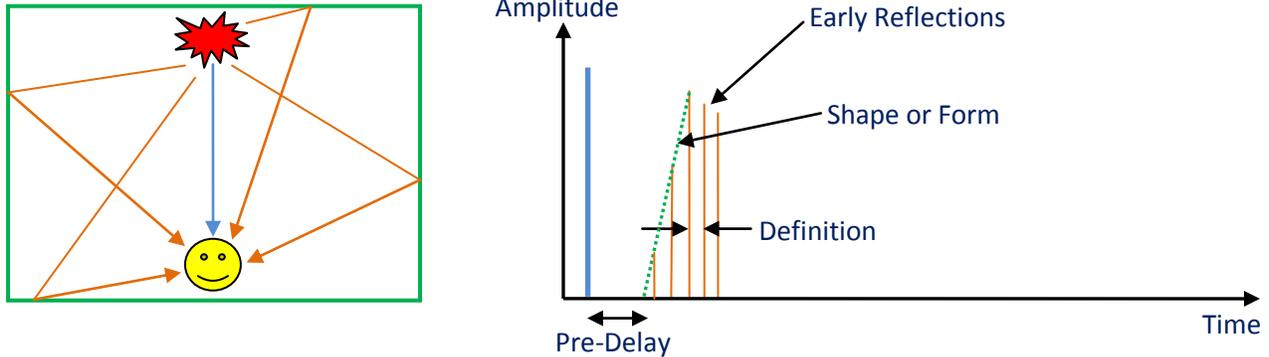


The plot describes the effect graphically. The initial sound has a certain amplitude (volume) and for the purpose of this explanation is assumed to be a short burst of sound represented here as a vertical pulse. If the sound was continuous then this pulse would be much wider, occupying an appropriate time span.

If there was no reverberation in the room this is all the sound we would hear.

2) The Early Reflections

A short time after we hear the initial sound we start to hear the reflected sound. This is caused by the initial sound now reflecting off the walls, floor and ceiling. There will be several of these reflections, known as *Early Reflections*. We hear them at different points in time since they bounce off different parts of the room and so travel different distances to our ears. Their sound waves will be smaller in amplitude than the initial sound wave since in reflecting around the room they will have to travel farther than the initial wave and so will have more of their energy absorbed by the air.



Now we can derive our first two reverberation parameters, both of which relate to the size of the room. The larger the room the longer the distance the reflections will have to travel and so the longer they will take to arrive at our ears. So the time delay between the initial sound and the arrival of the first Early Reflection and the time between each of the Early Reflections both give us a perception of how large or small the room is. The first parameter is known as the **Pre-Delay** and the second is the reflection density or **Definition**. The longer these values the larger we perceive the room to be. Later on the reflections become too numerous and dense to perceive individually so we get most of our room size information from this early part of the process.

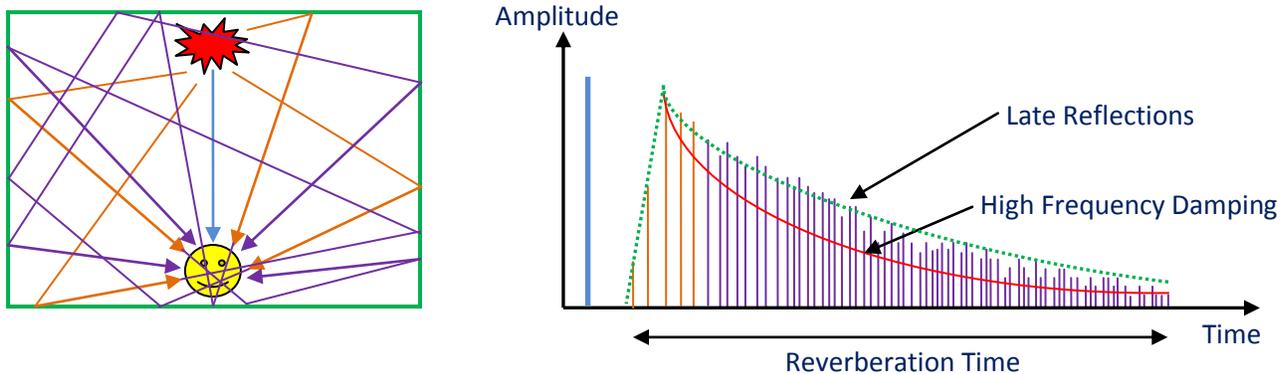
How quickly the Early Reflections build up will depend on where you are in the room relative to the source of the sound. If you are near to the source the buildup will be rapid, the reflections arriving quickly and in strength. If you are farther away then the buildup will be slower, the reflections being weaker and taking longer to arrive. The rate of this buildup forms the leading edge of the reverberation profile that we are plotting. This is often referred to as the reverberation attack and is represented by a **Shape** or **Form** parameter.

One further effect occurs due to the position of the listener relative to the sound source. As we have previously discussed, sound waves emanating directly from a source do so in all directions but because our ears are some distance apart and pointing in different directions any given sound wave will reach each ear at different points in time. This is the stereo imaging effect that we use to locate the position of a sound source. The same effect occurs with reflections, there will be a time difference between the arrival of a reflected wave at each ear. Some reverberation units emulate this effect by providing an option to separately define the timing of the Early Reflections. Typically this can be specified independently for the left and right ears both in terms of a different time delay for the first reflection (**Left** and **Right** parameters) and the subsequent amount of amplitude absorption by the room in between reflections.

The overall intensity of these stereo reflections can be controlled by a **Reflect** parameter which simultaneously adjusts both the left and right amplitudes to a common level.

3) *The Late Reflections*

The Early Reflections continue to bounce around the room for a further period of time multiplying in number and density. As they do so the room becomes awash with sound waves such that our ears now perceive an all encompassing reverberant sound field. These reflections are known as the *Late Reflections* and will eventually lose energy and die away. The rate at which this will occur will depend on the how reflective the room surfaces are, what absorbent material there is in the room, including the air, and also the size of the room. In the latter case we know that in larger rooms the time between reflections is greater so these will persist for a longer period of time. This effect is often represented by a **Size** or **Room Size** parameter.



The length of time it takes for the reflections to die away is known as the Reverberation Time. More specifically this is defined as the time it takes for the amplitude of the reflections to decay to 60 dB below their initial value. The reverberation time is adjustable with a **Time** parameter.

An additional effect also occurs during this time which is frequency dependent. Because higher frequencies are absorbed more quickly than lower ones the rate of decay of these frequencies in the sound waves is greater. The effect is shown by the red line on the plot. At any given point during the reverberation time the high frequency waves will always be of lesser intensity than the other frequencies. The extent to which this attenuation occurs is known as **Damping**. In addition to specifying the size of this damping we also need to specify a selected range of higher frequencies that the damping will apply to. To this end reverberation units often provide a **High EQ/Treble** parameter for this purpose, the implementation technology being that of an equaliser. In some environments we can also get a similar effect with the bass frequencies so in addition to the High EQ function, a **Low EQ/Bass** parameter can also be provided.

The overall volume of the reverberation is determined by the amplitude of its reflections. Too small an amplitude and the overall sound will appear dry, too large an amplitude and the sound will become excessively reverberant and indistinct. The amplitude of the reflections is adjustable by a **Reverb** or **Volume** parameter.

Although any individual sound source may be considered as monophonic we actually hear this in stereo. The degree to which the reverberation is spread across the stereo field can be adjusted by a **Diffuse** parameter.

Reverberation Units

An early form of reverberation unit was the *Echo Chamber* which was a small room designed to be extremely reverberant through the use of highly reflective materials. A loudspeaker provided the sound source and a microphone picked up the resulting reverberation. The arrangement had the advantage of generating a very natural reverberation but provided very little control over the reverberation parameters.

With the invention of tape recorders it became possible to construct a *Magnetic Tape Reverberation Unit* by placing several read/record heads in line along the tape. The original sound would be recorded then read back and re-recorded (overdubbed) several times at decreasing levels of amplitude. Although this arrangement worked to a certain degree the effect was more like an echo than reverberation because the heads needed to be placed closer together than was physical possible and so produced relative long re-record times.

A popular device in musical instruments particularly electronic organs was the *Reverberation Spring Unit*. This comprised a long flexible coiled spring suspended at both ends. At one end was attached a transducer to convert the electronic signal to a mechanical vibration which then rippled backwards and forwards along the length of the spring. A second transducer at the other end converted these mechanical reflections back again into an electronic signal. The unit worked reasonably well but tended to be somewhat noisy in operation with the inherent vibrations of the spring adding to the signal.

These days, reverberation units are constructed from dedicated signal processing computer chips known as *Digital Signal Processors (DSP)*. The original sound is sampled and multiple copies of this are generated at appropriate points in time and at suitable amplitudes to form the reflections. Because the process is essentially computational it's possible to define and control a wide range of reverberation parameters. This is the type of unit used in the OAS instruments.

The OAS Reverberation Controls

In a reverberation system a signal from a sound source is fed to the input of the reverberation unit and a proportion of the output from this unit is mixed with the original signal to form the final reverberated sound. Two sets of controls are required. Firstly we need to adjust the proportion of the reverberated signal in the mix and secondly we need to define the reverberation parameters. On an OAS instrument the amount of reverberated signal is controlled by the reverberation volume controls. Depending on the type of reverberation unit these are located either on the input mixer with a separate control for each sound generator or on the reverberation unit itself. The controls for the reverberation parameters are located on the reverberation unit.

There are two types of reverberation unit.

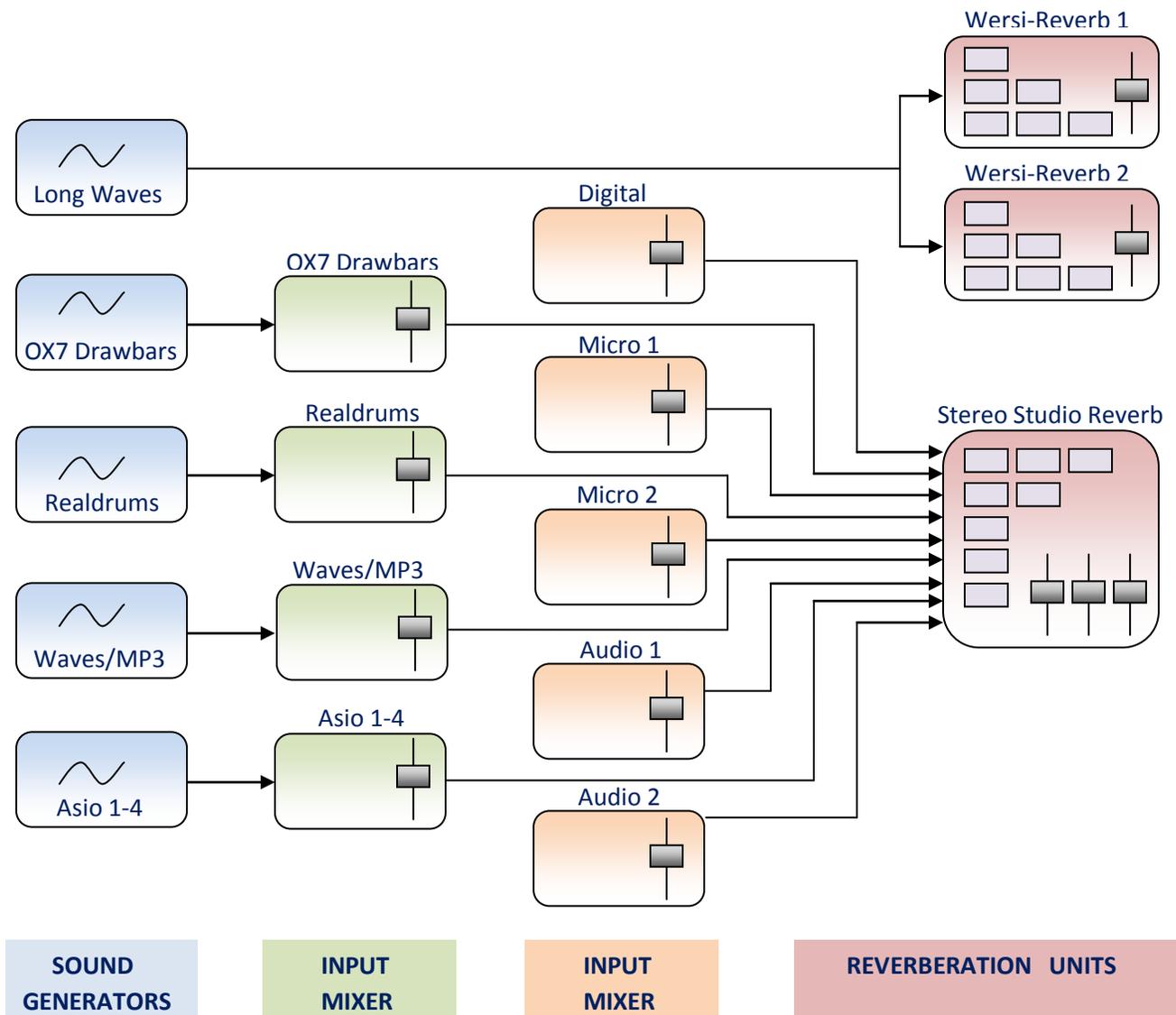
1) *Wersi-Reverb 1 / Wersi-Reverb 2 Unit*

This provides reverberation effects for the Long Waves sounds as used on the manuals/pedals, accompaniment and drums. It offers all of the main reverberation parameters.

2) *Stereo Studio Reverb Unit*

This provides reverberation effects for the OX7 Drawbar sounds, the Realdrums sounds, the Waves / MP3 signals, the four Asio channels, the Digital input and the external microphone and audio inputs. In addition to the main reverberation parameters it also offers a supplementary set of parameters that facilitate a more accurate emulation.

The following diagram illustrates the signal flow from the sound generators through the mixer controls and out to the reverberation units, adopting the same structure as seen on the input mixer menus.



As before, we can follow the signal flow through the system for the various sound generators and external inputs.

The Long Waves sounds are fed in parallel to the two reverbation units **Wersi-Reverb 1** and **Wersi-Reverb 2**. These provide identical functions for two types of reverbation either of which can be set differently for the manuals/pedals, accompaniment and drums. A reverbation volume control is provided on each unit to adjust the proportion of reverberated sound being mixed and there are controls to specify and adjust a range of principle reverbation parameters.

The signals for the OX7 Drawbar sounds, the Realdrums sounds, the Waves / MP3 signals, the four Asio channels, the Digital input and the external microphone and audio input signals are first fed to their respective Input Mixer menus where a separate reverbation volume control for each signal adjusts the proportion of this reverberated signal in the mix. This enables the intensity of the reverbation for each individual signal to be set. The signals are then passed to the **Stereo Studio Reverb** unit where a comprehensive set of reverbation parameters is provided.

Sound Quality Strategy

Reverberation units are designed to emulate a wide variety of listening environments. In musical terms this could mean anything from the intimacy of a small jazz club to the vast expanse of a symphonic concert hall. The strategy for setting up a reverberation unit for optimum sound quality is threefold.

Firstly we need to decide on the required listening environment. Secondly we then need to specify and adjust the reverberation unit parameters consistent with the characteristics of that environment. For example if we are setting up a reverberation environment for a church we should define a large room size and a long reverberation time. It would make no sense to set a small room size when a church is such a large building. Thirdly we need to ensure that the mix of original sound from the sound source and the reverberated sound are appropriately balanced so that the overall effect has depth but is clear and distinct and is properly suited to the acoustics of the environment in which the organ is being played. In this last regard it should be noted that the sound from any given reverberation unit will be affected by any additional reverberation present in the playing environment. The first two objectives are implemented by the parameters on the reverberation units, the third by the reverberation volume controls.

In setting up the reverberation unit it is useful to divide the reverberation parameters into two types, namely *Primary* and *Secondary* controls. The primary controls are those that have a significant effect on the reverberated sound whilst the secondary controls provide fine adjustment.

Primary Controls

The Primary Controls are **Room Size**, **Pre-Delay**, **Density/Definition**, **Reverberation Time** and **Reverberation Volume**. All of these parameters between them define the main characteristics of the reverberation, namely intensity, depth and length.

Secondary Controls

The Secondary Controls are **Shape/Form**, **Damping**, **High EQ/Treble**, **Low EQ/Bass**, **Left** and **Right** reflections with associated damping, and reflection volume **Reflect**. These parameters have a more subtle effect on the reverberated sound,

The strategy in setting up the reverberation system should be first to adjust the primary controls to define the main body of the reverberation, then to adjust the secondary controls to refine the effect, and finally to set the reverberation volume such that the overall sound is neither too dry nor too indistinct.

OAS instruments provide a facility for defining different reverberation environments by use of the *Sub-Presets* function. This enables a particular set of reverberation unit parameters to be stored and recalled when a preset is selected. How much use is made of this facility will depend on personal preferences. You may wish for example to define a different setup for each type of musical style to reflect the environment in which that style of music would normally be played. Alternatively you may be content to define a general purpose setup that could be used for a wide variety of musical styles.

To accommodate these two requirements we will construct a strategy for setting up a medium sized concert hall for the orchestral sounds and a corresponding arrangement for the drawbar sounds. Both of these will also serve as general purpose reverberation settings. Once familiar with this procedure the process can then be applied to the implementation of any other larger or smaller environment.

Implementation

The sound quality strategy for setting up the reverberation units will be implemented in two stages, first for the Long Waves sounds using the Wersi-Reverb 1 / Wersi-Reverb 2 units and then for the OX7 Drawbar sounds, Realdrums and any installed VST packages using the Stereo Studio Reverb unit.

Long Waves Sounds

Reverberation for the Long Waves sounds on the instrument is provided by the Wersi-Reverb 1 and Wersi-Reverb 2 units. The Wersi Reverb-1 unit provides the primary reverberation for these sounds whilst the Wersi Reverb-2 unit if set up differently can be used to add supplementary effects.

Effects Menu

Call up the Effects menu from the Main Display page by selecting the **Effects** button from the top menu bar. Now you will see selection buttons for the two Wersi Reverb units (*Reverb1*, *Reverb 2*) and the Stereo Studio Reverb unit (*Reverb*).

Reverb 1 Menu

Select the **Reverb 1** button to display the Wersi- Reverb 1 menu and ensure that the **Manuale** button in this menu is selected.



We shall now define a set of reverberation parameters for the concert hall consistent with an environment of this size. These parameters can vary between a minimum value of 0 (no effect) and a maximum of 127 with a value of 63 being the average.

Primary Parameters

The hall is of medium size so values for Room **Size** (90), Reverberation **Time** (84) and Reverberation **Volume** (77) will be tending towards the higher end of the range. The **Pre-Delay** (20) will typically be about a quarter of the Reverberation Time.

Secondary Parameters

In a hall of this size there will be higher than average absorption of the high frequency content in the reverberation with more than half of the low and high frequencies being absorbed. However concert halls generally have some degree of acoustic compensation in their design so average values for **Damping** (63), **Low EQ** (63) and **High EQ** (63) are appropriate. A higher than average value for **Shape** (76) will place the listener in the main body of the audience experiencing a slightly slower reverberation buildup.

Enter each parameter on the Wersi-Reverb 1 menu as shown below by selecting its value box and adjusting to a higher or lower value with the tempo wheel.

Play selected Long Waves sounds on the manuals and adjust the Reverberation **Volume** control if necessary to achieve an overall mix that is significantly reverberant but in which the selected sounds are clear and distinct.



Once having set up the Wersi-Reverb 1 unit it is necessary to save this configuration as a reverberation preset and set this as your standard setting so that it is permanently stored for use in your total presets. Select the **Save** button on the menu and choose a free location from the drop down list. You can change the name of the preset if you wish by selecting the grey name bar, entering a new name with the displayed keyboard and confirm by selecting the **Enter** button. Now select the **Save Preset** button to store the preset. To set this as your standard setting select the **Standard** button on the Wersi-Reverb 1 menu and confirm by selecting the **Yes** button when asked 'Do you want to save this setting as Standard'

Accompaniment and Drums Reverberation

The reverberation system enables you to set up different reverberation environments for the Accompaniment and Drums sounds by repeating the above procedure and creating a different preset for each. However, in this case all these instruments will be performing in the same environment so they can all use the same preset. Select the **Accomp** button and ensure that the reverberation preset you have just defined and set as standard, as indicated by (STD) after its name, is selected from the drop down list. Repeat this process for the **Drums** button. Later on if you wish you can set either or both of these differently.

Reverb 2 Menu

Select the **Back** button on the Wersi-Reverb 1 menu to return to the Effects menu. Here you can select the **Reverb 2** button to display the Wersi-Reverb 2 menu. The menu is identical to the Reverb 1 menu. The reverberation system enables you to mix together the settings of these two menus for those Long Waves sounds that employ both units. The Reverb 1 unit provides the dominant reverberation whilst the Reverb 2 unit adds a more subtle lower level effect if configured with a different set of parameters. A concert hall environment is unlikely to produce this duality so we can set up the Reverb 2 unit with identical parameters to those of the Reverb 1 unit. Follow the same procedure as before entering the same parameters, save as a preset and set this as standard. You will now have a separate standard preset for each unit but containing identical parameters. Later on if you wish you can set these differently.

OX7 Drawbar Sounds

Reverberation for the OX7 Drawbar sounds on the instrument is provided by the Stereo Studio Reverb unit. Select the **Reverb** button on the Effects menu to display the Stereo Studio Reverb menu.

We shall define a set of parameters for this unit that is comparable with those specified for the Wersi-Reverb 1 / Wersi-Reverb 1 units. In this way when instrumental and drawbar sounds are mixed together the combined reverberation will be compatible.

The unit provides two controls that affect the reverberation volume, **General** which controls the overall volume of the unit and **Reverb** which controls the volume of the reverberation. As we have discussed previously this unit provides reverberation for a number of sound sources. The individual volume of each of these is controlled by a volume control on their respective Input Mixer menus. So we can use the General control to balance the volume of the unit with the other reverberation units on the instrument whilst setting the Reverb control to maximum enables the reverberation volume of each sound source using the unit to be individually adjusted by the Input Mixer controls.

A useful feature on the menu for this unit is a graphical display of the reverberation profile that we constructed in the *Basic Principles* section. The shape of this profile dynamically adjusts to the settings of the primary parameters.

Primary Parameters

Values for **Room Size** (90), Reverberation **Time** (84) and **Pre-Delay** (20ms) are as before. Reverberation volume **Reverb** (0 dB) is set to maximum and general volume **General** (3 dB) is set to match the output of the Wersi-Reverb units.

Secondary Parameters

In the Reverb Settings section of the menu, damping for drawbar sounds since they are electronic rather than natural, isn't particularly relevant. The highest frequency generated by the drawbar system is 4 kHz (top C of the 1' drawbar) so damping can be set to anything above this value. **Damp** (7.0 kHz) will achieve clarity across the entire frequency range. **Diffuse** (127) gives the widest stereo separation and **Definition** (90) ensures that the spacing between the Early Reflections matches the room size. **Form** (76) defines the same reverberation buildup as before.

In the Input-EQ section of the menu set the controls **Bass** (30 Hz) and **Treble** (12.0 kHz) to their minimum and maximum values respectively so that none of these frequencies are attenuated.

In the Reflections section of the menu, the stereo reflections are shown as two sets of vertical markers on the reverberation profile, five for the left channel and five for the right. The timing of the stereo reflections should be of the same order as the Pre-delay since they define the start of the Early Reflections, but we can vary the values to the left and right ears to make the effect more realistic, for example **Left** (20 ms) and **Right** (40ms). The amplitude of the stereo reflections is the amplitude of the Early Reflections so these should be of the same height as the leading edge of the reverberation profile, **Left** (0 db) and **Right** (0db) will achieve this.

In the Reverb To section of the menu we can define the volume of the reverberation in the delay and chorus effects. For now we can set these to their maximum values of **Delay** (0 db) and **Chorus** (0 dB). They can be changed later if required.

The Stereo Studio Reverb menu should now look as shown below.



As before, once having set up the Stereo Studio Reverb unit it is necessary to save this configuration as a reverberation preset and set this as your standard setting so that it is permanently stored for use in your total presets. Select the **Save** button on the menu and choose a free location from the drop down list. You can change the name of the preset if you wish by selecting the grey name bar, entering a new name with the displayed keyboard and confirm by selecting the **Enter** button. Now select the **Save Preset** button to store the preset. To set this as your standard setting select the **Standard** button on the Wersi-Reverb 1 menu and confirm by selecting the **Yes** button when asked 'Do you want to save this setting as Standard'

OX7 Drawbar Reverberation Control

Call up the Input Mixer menu from the Main Display page by selecting the **Mixer** button from the top menu bar. Select the **Edit** button on the **Organ** gain control to move to the Organ Inputs menu. Select the **Drawbars** button from the Advanced Organ Inputs section of the menu to display the OX7 Inputs menu as shown opposite.

Set the **Reverb** slider to -7 dB, play selected drawbar sounds and adjust if necessary to obtain a good mix of original and reverberated signal.



Save this new setting by repeatedly selecting the **Back** button to return to the Mixer Inputs menu. Select the **Save** button on the Mixer Inputs menu and save using your previously defined standard preset name.

Realdrums and VST Reverberation Control

The settings on the Stereo Studio Reverb unit are also utilised by the Realdrums sound generator, any VST packages that you may have installed in the Asio slots as well as the Digital, Waves/MP3, microphone and audio inputs. For any given reverberation preset they all share the same settings but as with the OX7 Drawbar sounds the relative volumes of each can be controlled by their respective **Reverb** sliders on the Input Mixer.

Repeat the above process for each of these sound sources, selectable from the Advanced Organ Inputs section of the Organ Inputs menu.

Hint and Tips for Setting up Different Reverberation Profiles

Once having configured the reverberation units with this general purpose reverberation setting you may wish to create other reverberation presets with different characteristics. When defining other configurations :-

- Maintain the same proportions between each of the parameters
- For a longer deeper reverberation increase the primary parameters
- For a shorter shallower reverberation reduce the primary parameters
- For a brighter reverberation reduce the damping and increase the Treble / High EQ
- For a mellower reverberation increase the damping and reduce the Treble / High EQ

This concludes the reverberation part of the setup procedure. You can now proceed to Part 4 to set up the Bass Controls of the instrument.
