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The Grand Organ in the Sydney Opera House

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Abstract – The building of the Opera House Organ is a milestone in the world of music. The Concert Hall has provided a unique opportunity for the installation of what will be the world's largest mechanical action pipe organ in the best position possible, acoustically and visually.

The organ specification includes all schools of organ building that are considered to have aesthetic and historical validity so as to be able to demonstrate these characteristics to the people of Sydney. Every family of stops is represented, but no stop is redundant. The organ will not only be able to interpret these various schools but will have an overall character and musical unity if its own.

[*Compiler's Note: Click on thumbnails to view figures and diagrams at larger scale. Figure 7 – Specifications is not reproduced. It is a montage of typescript pages, illegible without a strong magnifier and not readily reproduced in this medium.*]

1. Introduction

From an early stage it was decided to have a large fixed organ in the Concert Hall, which could be used for solo work or with orchestra, choir or chamber music groups. It would also be used at ceremonies and conventions and must be able to play popular music.

The organ would therefore have to be a large comprehensive instrument. It must be suitable both for solo use and as an accompanimental instrument. To be successful it must be able to demonstrate to people in Sydney the best characteristics of the different national schools, past and present, that are considered to have aesthetic or historical value.

Despite its versatility in being able to play music in the correct tone for these different national schools the organ must have a musical unity and be able to succeed for itself as a solo instrument. It cannot be purely imitative but must have an overall character and musical unity of its own.

It is hoped that an organ with the above characteristics will excite the attention of Australian composers. The Concert Hall in the Opera House provided a unique opportunity to install such

an organ in the best musical, acoustical and visual location high up on the front wall. As in many of the famous cathedrals in Europe, this has always been considered the optimum position.

To achieve these musical aims, it is necessary to use relatively low wind pressure and mechanical playing action throughout. The nature of the project is such that only the finest of pipe metals and materials have been used.

In an organ of this size, operating convenience becomes an important element. An unusually versatile system of stop control and registration aid has been devised using the latest developments in electronic technology.

The organ is scheduled to be completed in 1976.

2. Overall Design of the Organ

The organ is contained in a specially built shell-shaped concrete chamber 15 m (46 ft) high and stands on a cantilevered steel platform which overhangs the audience seating. The front pipes of the façade are in line with the walls of the Concert Hall and the depth of the organ is approximately 6 m (18 ft). The console is located on an extension of the organ platform and is approximately 2 m (6 ft) in front of the organ. On either side of the console is the Ruckpositiv division, so divided to allow the audience to see the organist.

Figure 1 – The façade of the organ showing the position of the console and disposition of the various departments

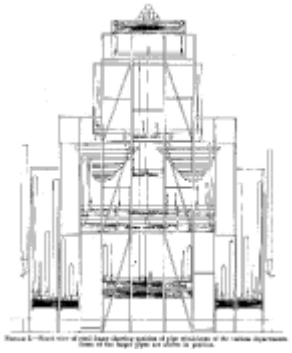

Figure 2 – Front view of steel frame showing position of pipe windchests of the various departments. Some of the larger pipes are shown in position

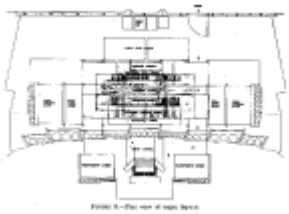

Figure 3 – Plan view of organ layout

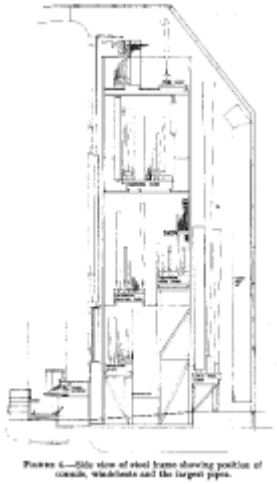

Figure 4 – Side view of steel frame

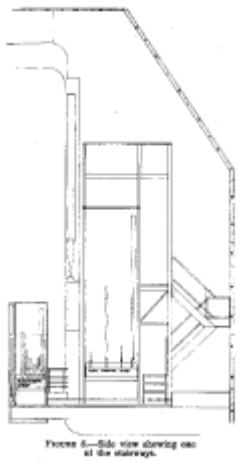

Figure 5 – Side view showing one of the

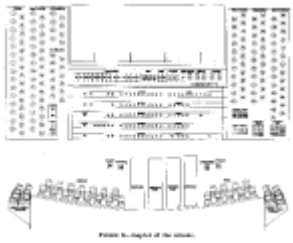

Figure 6 – Layout of the

showing position of console, windchests and the largest pipes

stairways

console

The Brustwerk division, with its 4 ft show pipes, is situated in the main case immediately above the console.

The Hauptwerk division, with its 16 ft show pipes, is situated above the Brustwerk.

The Oberwerk is above the Hauptwerk and behind the top group of show pipes, and the Kronwerk at the very top of the organ.

The large pedal pipes are contained in the front on each side and at the rear of the organ chamber, the smaller pedal pipes are on each side of the organ chamber.

The frame of the organ is of special steel sections and welded on the site. It contains stairways and a spiral staircase for easy access to the different divisions.

Access to the organ is from outside the Hall via a spiral staircase to the rear of the organ chamber. The organist then walks through the organ to the console, some 10 m (30 ft) above the main floor of the Hall.

The largest pipes of the organ belong to the Prinzipal 32 ft, the biggest four are constructed of 50 mm (2 in) thick marine plywood and are hung on the rear wall.

Because of the distance of the console from the conductor, a number of communication aids are built into the console. These include two closed circuit television screens giving the organist views of the conductor and of the stage, a speaker from the stage to the organist, a telephone from the organist to the conductor and stage manager and a microphone to enable the organist to speak over the public address system.

3. National Tone Characteristics

Examples of some of the national schools of organ building as represented in the Opera House organ are shown by the following specifications. By comparison, it is possible to see how these have influenced the total design of the organ.

Examples represented are:

English : Trinity College, Cambridge, 1860—Hill.
Classical French: Ste. Gervais, Paris, 1768—Cliquot.
Romantic French: Ste. Clothilde, Paris, 1858—Cavaillé-Coll.
Italian : St. Guiseppe Brescia, 1581—Antegnati.
North German: St. Jacobi, Hamburg, 1688—Schnitger.

ENGLAND

Typical Specification of Organ by William Hill, 1860

Great Organ	Choir Organ	Solo Organ	Swell Organ	Pedal Organ
Double Open Diapason 16’	Double Dulciana 16’	Harmonic Flute 8’	Double Diapason 16’	Sub-bourdon 32’
Open Diapason 8’	Dulciana 8’	Harmonic Flute 4’	Open Diapason 8’	Open Diapason 16’
Salicional 8’	Open Diapason 8’	Vox angelica 8’	Salicional 8’	Open Diapason 16’
Gamba 8’	Claribel 8’	Lieblich Flute 4’	Cone Gamba 8’	Violon 16’
Stopped Diapason 8’	Viola da Gamba 8’	Piccolo 2’	Stopped Diapason 8’	Bourdon 16’
	Stopped Diapason ‘	Tuba mirabilis 8’	Suabe Flute 4’	Principal 8’

Quint 5 1/3’	Stopped Flute 4’	Vox humana 8’	Principal 4’	Base Flute 8’
Principal 4’	Principal 4’	Orchestral Oboe 8’	Fifteenth 2’	Fifteenth 4’
Wald Flute 4’	Flautino 2’		Mixture III	Mixture III
Nason 4’	Cremona 8’		Double Trumpet 16’	Trombone 16’
Twelth 2 2/3’			Trumpet 8’	Clarion 8’
Fifteenth 2’			Cornopean 8’	
Full Mixture III			Oboe 8’	
Sharp Mixture II			Clarion 4’	
Trumpet 8’				
Clairon 4’				

The Sydney Town Hall organ, built in 1886, represents the culmination of English romantic organ building by William Hill and is an entirely different concept to the Opera House organ.

FRANCE

Typical Specification of Organ by Cliquot, 1768

Grand Orgue	Positive	Bombarde	Récit	Echo	Pedale
Montre 16’	Flûte 8’	Bombarde 16’	Cornet III	Flûte d’echo 8’	Flûte 16’
Bourdon 16’	Bourdon 8’		Hautbois 8’	Trompette 8’	Flûte 8’
Montre 8’	Prestant 4’				Flûte 4’
Bourdon 8’	Nazard 2 2/3’				Bombarde 16’
Flûte 8’	Quarte de Nazard				Trompette 8’
Prestant 4’	2’				Clairon 4’
Nazard 2 2/3’	Tierce 1 3/5’				
Doublette 2’	Plein jeu IV				
Quarte de Nazard	Trompette 8’				
2’	Cromorne 8’				
Tierce 1 3/5’	Basson-Clarinette				
Grand Cornet V	8’				
Plein jeu VI	Clairon 4’				
I. Trompette 8’					
II. Trompette 8’					
Voix humaine 8’					
Clairon 4’					

FRANCE

Typical Specification of Organ by Aristide-Cavaillé-Coll, 1858

Grande Orgue	Positiv	Récit	Pedale
Montre 16’	Bourdon 16’	Bourdon 8’	Quintaton 32’
Bourdon 16’	Montre 8’	Flûte Harmonique 8’	Contrebasse 16’
Montre 8’	Gambe 8’	Voile de Gambe 8’	Flûte 8’
Gambe 8’	Flûte Harmonique 8’	Voix Céleste 8’	Octave 4’
Flûte Harmonique 8’	Bourdon 8’	Flûte Octaviante 4’	Bombarde 16’
Bourdon 8’	Salicional 8’	Octavin 2’	Basson 16’
Prestant 4’	Prestant 4’	Basson-Hautbois 8’	Trompette 8’
Octave 4’	Flûte Octaviante 4’	Voix Humaine 8’	Clairon 4’
Quinte 2 2/3’	Quinte 2 2/3’	Trompette 8’	
Doublette 2’	Doublette 2’	Clairon 4’	
Plein Jeu V	Clarinette 8’		
Bombarde 16’	Trompette 8’		
Trompette 8’	Clairon 4’		
Clairon 4’			

ITALY

Typical Specification of Organ by Antegnati, 1581

1. Principale 16’
2. Principale 16’
3. Octua 8’
4. Decima quinta 4’

5. Decima nona 2 2/3'
6. Vigesima seconda 2'
7. Vigesima sesta 1 1/3'
8. Vigesima nona 1'
9. Trigesima terze 2/3'
10. Flauto in quintadecima 4'
11. Flauto in duodecima 5 1/3'
12. Flauto in ottaua 8'
13. Fiffaro (voce humane) 8'

GERMANY
Typical Specification of Organ by Arp Schnitger, 1688

Hauptwerk	Ruckpositiv	Brustwerk	Oberwerk	Pedal
Prinzipal 16'	Prinzipal 8'	Holzprinzipal 8'	Prinzipal 8' Holzflöte 4'	Prinzipal 32' Oktave 16' Sub-bass 16'
Quintatön 16'	Gedeckt 8'	Oktave 4'	Rohrflöte 4'	Oktave 8' Oktave 4'
Oktave 8'	Quintatön 8'	Hohlflöte 4'	Oktave 4'	Nachthorn 2' Mixture
Spitzflöte 8'	Oktave 4'	Waldflöte 4'	Spitzflöte 4'	6–8 ranks
Gedeckt 8'	Blockflöte 4'	Sesquialter 2 ranks	Nasat 2 2/3' Oktave 2'	Rauschpfeife 3 ranks
Oktave 4'	Nasat 2 2/3'	Scharff 4–6 ranks	Gemshorn 2'	Posaune 32' Posaune
Rohrflöte 4'	Oktave 2'	Dulzian 8'	Scharff 4–6 ranks	16' Dulzian 16'
Superoktave 2'	Sifflöte 1 1/3'	Trechterregal 8'	Zimbel 3 ranks	Trompete 8'
Flachflöte 2'	Sesquialter 2 ranks		Trompete 8'	Trompete 4' Kornett 2'
Rauschsfeife 3 ranks	Schaff 4–6 ranks		Vox humana 8'	
Mixture 6–8 ranks	Dulzian 16'		Trompete 4'	
Trumpete 16'	Bärpfeife 8'			
	Schalmei 4'			

4. Tonal Design

4.1. Frequency Range of the Organ

A stop is labelled in terms of the type of tone it produces, e.g. Prinzipal, Flute, Trompet, and the pitch of the sound in relation to piano pitch. The pitch is specified in terms of the longest pipe in the rank. Thus a stop labelled 8' pitch represents a rank of open pipes ranging from 8 ft in length two octaves below middle C through five octaves to a ¼ ft pipe.

A stop labelled 4' would sound an octave higher and 16' an octave lower.

The frequency range of the organ is from 16.35 Hz (32 ft) to 16,744 Hz at 1/32 ft 10 mm (3/8 in).

4.2. The Overall Concept

The overall concept was to approach the design and voicing of the organ from a detached musical point of view; from the position of a listener accustomed to orchestral and recital concerts rather than from the position of an organ enthusiast or that of a trained organist who expects certain traditional concepts; a view of balance, blend, freedom from harshness and extraneous noise, a singing quality.

The voicing of the Hauptwerk and Positiv will be similar except that the Hauptwerk is larger scaled and on a higher wind pressure, therefore being slightly louder; so that by selection of the appropriate Hauptwerk mixtures, e.g. Scharff and Zimbel with the foundation stops, an Italian-like plenum is possible, though without the possibility of adding individual ranks of upper pitches.

The speech and tone of the whole organ is unforced, so tending to be inoffensive and not tiring to the ear. Adequate loudness and the effect of fulness is obtained by the fact that most upper ranks break back at the 1/8 ft pipe to the 1/4 ft pipe. This concentrates the highest proportion of energy of sound in the fundamental pitch range 2,000–5,000 Hz which, on the Fletcher-Munson curves is the area of greatest sensitivity of the ear. This breaking sequence spreads the pitch range 2,000–5,000 Hz over the entire compass of the keyboard.

4.3. The Purpose of the Upperwork

(a) To duplicate the harmonics of the foundation ranks and so increase their power and loudness.

(b) By giving emphasis to different harmonics, formats are produced which alter the character of tone, as well as the loudness.

(c) The pitches and breaks of the Upperwork mixtures may be arranged to vary these formats according to the different positions in the compass, so producing a human singing quality which may have a different character on different manual departments.

4.4. Hauptwerk Division

In the Hauptwerk (main organ chorus) the provision of many mixtures of different composition will allow formats resembling those of the Italian, French and German schools to be produced. Basically, this division is the author's own concept of organ chorus and tone, containing elements of French, Italian and German character.

4.5. Oberwerk

This large division is contained in a swell box which has, as well as the main front shutters, a separate set of shutters opening at the rear of the box for echo effect. Essentially it is North German Schnitger in tone, with elements of French romantic school.

4.6. Ruckpositiv

This division is basically Italian in concept but contains elements of French and German characters.

4.7. Brustwerk

This division with swell shutters is enclosed within the lower case of the organ and is basically a Comet depicting the classical French echo Comet. It also contains examples of early German short length reeds, the Brustwerk of the Gothic organ in St. Jacobi, Lübeck and modern mutations.

4.8. Kronwerk

This division is situated above the Oberwerk right at the top of the organ and is basically a solo department. It contains three ranks of brilliant sounding trumpets and a Vox Humana all "en chamade", that is, lying horizontal and pointing directly into the Concert Hall. There is also a powerful twelve-rank Comet and an Ophicleide of sonorous quality.

4.9. Pedal

This division contains a cross-section of the elements of typical French, English and German classifications, plus additional and separated synthesizing upper partials of the fundamental pitch in order to produce, in the ear of a listener, a resultant fundamental of high power.

The author feels that this is musically preferable to gaining fundamental strength in the bass by the use of excessively energized large pipes. In the latter case, the absorption of the room acoustics in the very low organ bass range would require such a large energy input to the large pipes that the upper harmonics would become harsh and unblending. The pedal does in fact have large scaled heavyweight 32 ft and 16 ft ranks, but the energy input to these is sufficient only to provide a pure foundation of moderately low power which may be used with the softest stops of the organ. Increase in power is then obtained by reinforcement of the harmonics by the upper ranks.

5. Accessories and Controls

5.1. Accessories

A tremulant is provided for each department, including the pedal organ, and there are controls to adjust the tremulant speed and depth. A Glockenspiel of 73 bronze hand bells, 24 of which are visible, and a Carillon of 24 bronze hand bells are operated electrically and playable from the keyboard and pedal board. The Carillon or Zymbelstern is comprised of six bells selected from the 24 and struck one after the other in a preselected order. They may be selected for the appropriate key signature. The speed at which these bells are struck is also adjustable. The Glockenspiel is fitted with a reiterating control, which may be adjusted to give from one stroke to many strokes per key operation.

Balanced swell pedals control the Oberwerk main and echo shutters and the Brustwerk shutters. Direction reverse switches are fitted. Digital displays give an indication of the position of each of the swell shutters.

A crescendo pedal operates on all the registers of the organ. It controls the stops directly with no movement of the draw stops or rocking tablets on the console. It operates in addition to the stops already in use and provides a gradual build up from the softest stop on the organ to full organ when the normal crescendo piston is pressed. Three pre-set pistons are available to allow the organist to move to a crescendo setting independently from the stops selected by the draw stops and rocking tablets. The crescendo pedal, then, will control the stops from this pre-set position and the organ will return to normal stop operation when the crescendo off piston is pressed. A digital display indicates the state of the crescendo at all times and allows accurate control to any of the 171 positions. The crescendo pedal itself gives a rate control rather than the positional control of the swell pedals. This allows easier control of slow build ups.

5.2. Controls

Because of the large number of stops, a very versatile system of stop control and registration aids has been included. These allow easy and instant operation of the stops and couplers. The drawstop action is electric and the combination piston action is electronic.

Four manual to pedal couplers operate by mechanical key action, as does the Brustwerk to Oberwerk coupler. The other manual and pedal couplers are operated by electric action. Rocking

tablets above the top keyboard operate octave couplers and two couplers connecting manual and pedal pistons.

The piston mechanism is a full capture unit which allows the organist to select any required number of stops on any piston. Fifteen pistons control the whole organ and each division has nine independent pistons. The piston unit has a tape recorder fitted which allows all the piston settings to be recorded on cassette tapes. One cassette will record approximately 100 complete settings, and to record, or re-set, the organ takes approximately 12 seconds.

The player unit is a new development which enables the organist to record his performance on cassette tape, which can then be played back on the organ itself. This is possible through the additional fitting of electric action, as well as the mechanical key action. On replay the organ operates by electric action but simulates the timing of the original performance as accurately as is possible, considering the limitations of the recording medium. The organ faithfully follows all stop changes, piston operations, swell and crescendo pedal movements.

The organist can control the replay of the organ from a position in the audience seating. He can, from this position, alter the stop settings, swell positions and piston settings, if he feels it necessary. These new settings remain programmed in the organ.

By recording one part of the score, e.g. orchestral accompaniment, the organist may play the organ through its normal mechanical action against this recording, to practise, e.g., organ concertos. It will also be possible for the stage manager to play the organ from tapes during conventions and conferences and for the benefit of visitors, if an organist is not available.

6. Technical Details-Summary

The organ has five manuals and pedal and contains approximately 10,500 pipes, of which 109 are visible. There are 205 ranks of pipes grouped into 127 speaking stops, with 28 couplers. The front show pipes are of 95% tin, 5% lead and are burnished to a mirror-like finish. The largest front pipe is E in the 32 ft octave with a diameter of 430 mm and a length of 9.26 m. It weighs 340 kg.

There is a Glockenspiel of 73 bronze hand bells, 24 of which are visible, and a Carillon of 24 small bronze hand bells. The Tympanon operates a soft bass drum roll and there is an imitation cuckoo and nightingale.

Power for the organ is via two DC (direct current) rectifiers supplying 400 amps at 17 volts. The wind supply is by nine electric centrifugal blowers, each one contained in a silencing box equipped with BW (bromochlorodifluoromethane) gas fire extinguishers and temperature sensing alarm. A sprinkler system is also built into the organ chamber.

The total weight of the organ is 37 tonnes.

Acknowledgement

The diagrams in this article were reproduced by kind permission of Hall, Todd and Littlemore, Architects.

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