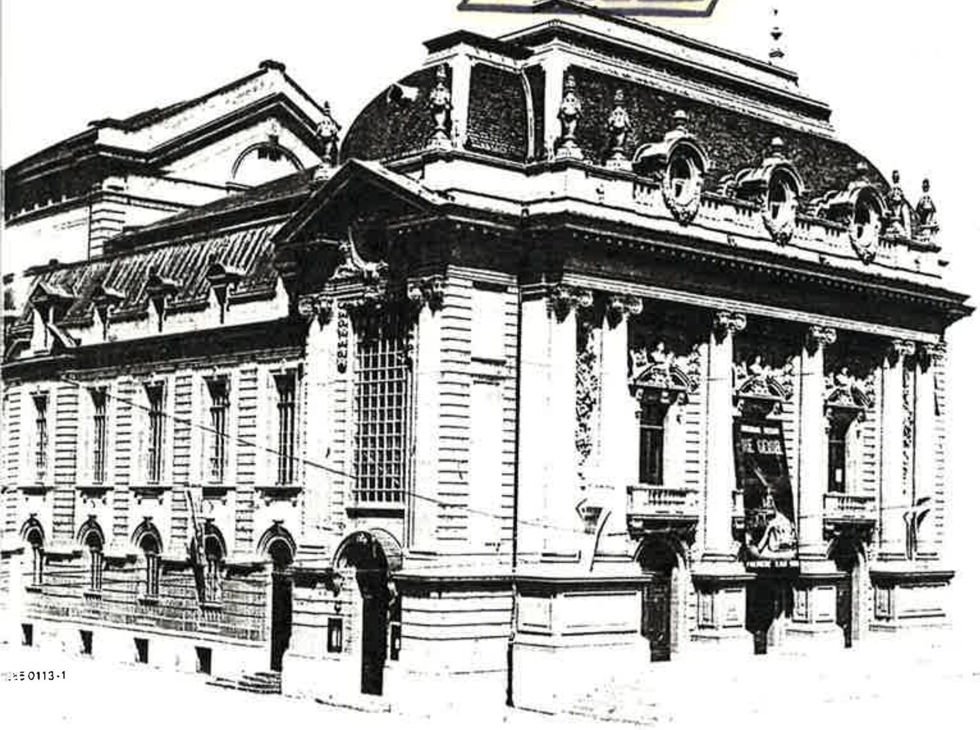
New Theatre Climate in Berne

1956

W. Todt, Heating and Air Conditioning Division



1 Main entrance of the Municipal Theatre, Berne.

A theatre offers a particularly varied working field for air conditioning and heating engineers. Besides the very different conditions demanded, the spaces involved vary greatly in size. In the Municipal Theatre of Berne, for example, they range from the stage shaft occupying some 10 000 m³ to the actors' dressing rooms of only a few cubic metres each.
Similar assignments have been handled by Sulzer in recent years, including the Municipal Theatre in Winterthur, the European World Trade and Convention Center in Basle, the Raimund Theatre in Vienna, the "Hans-Martin-Schleyer-Halle" in Stuttgart, the UNESCO Conference Rooms in Paris and the Congress and Concert Building in Lille.

The Municipal Theatre in Berne opened its doors for the first time in 1903. The building is a restrained blend of art nouveau and neoclassic. At the time its technical facilities were state of the art, but after 75 years a general overhaul and modernization were due. Owing to weathering and environmental influences, the façade of Bernese sandstone had suffered considerably, while the technical equipment was outworn and obsolete, especially backstage. An assessment by Prof. Zotzmann pointed to the urgent need for security measures and modernization. The credit requested for a thorough renovation was approved by the citizens of Berne in a referendum held 1979.

One important prerequisite was the maintenance of the architectural substance, which ranked as a listed building.

Already 1980 the façade renovation was begun, and by temporary measures it was possible to keep the theatre working till June 1982.

Planning of the reconstruction operations and coordination of the various specialized engineers were directed by the Berne architects Spörri & Valentin AG. The interests of the owners (i.e. the municipality) were safeguarded by the Building Directorate of the Municipal Civil Engineering Department.

After 28 months of work, on 28th October 1984 the festive reopening took place with Richard Wagner's "Tannhäuser" (as at the 1903 première). The security measures and modernization cost altogether about 32 million Swiss francs [1, 2] (*Figs. 1–3*).

Building services

In a theatre there are all kinds of rooms, and the building services are correspondingly varied. Air conditions appropriate to requirements must be provided on the one hand for the audience, actors and stage hands, and on the other hand to suit special working procedures and materials (*Table 1*).
In addition there were demands peculiar to the theatre, such as:

- high and rapidly changing internal heat loads from people and lighting,
- exacting acoustic standards,
- large spaces to be served, especially the auditorium and the stage shaft.

SULZER was entrusted with the engineering of the air conditioning and heating facilities. The installation work for these two main systems was divided into two lots each. The technically more sophisticated lot in each case was handled by the SULZER branch in Berne.

Table 1: Technical data

Building	
Auditorium seats	700–800
Musicians in orchestra pit	40–80
Maximum sound pressure levels L_A, measured 1 m from air inlets and outlets	
Auditorium and orchestra pit	28 dB
Stage shaft and understage	30 dB
Outside, 3 m in front of the building	50 dB
Outdoor air states taken for calculation	
Winter: temperature	−11 °C
relative humidity	90%
Summer: temperature	30 °C
relative humidity	46%
temperature for refrigerating plant	28 °C
Room air states	
Auditorium, summer and winter	23 °C
tolerance	±1 K
winter: relative humidity	35%
Cloakrooms, winter, minimum	20 °C
Stage costume making, winter, minimum	20 °C
Other workshops, minimum	20 °C
Understage, minimum	18 °C
Heating	
Primary district heating network	175/85 °C
Secondary network, main distribution	105/75 °C
Radiators (existing)	105/90 °C
	90/70 °C
(new)	90/70 °C
	80/60 °C
Air installations	70/50 °C
Capacities	
District heating	1330 kW
Refrigeration for air conditioning	206 kW
Steam generation for air humidification	100 kg/h
Supply air volume flows	
Auditorium pit	10800 m³/h
1st circle	6600 m³/h
2nd circle	5500 m³/h
3rd circle	6200 m³/h
Orchestra pit	2500 m³/h
Stage management and lighting control	2800 m³/h
Stage shaft	9600 m³/h
Cloakrooms	3600 m³/h
Understage	5500 m³/h
Various workshops	15900 m³/h
Transformer, battery rooms etc.	
Total	69000 m³/h


2 Interior of the Municipal Theatre, Berne. The orchestra pit is covered for a play, enlarging the stage and also adding two rows to the auditiorium seating.


3 The interior looking from the stage towards the three circles and the dome with the circular air extraction.


4 Radiator in a staircase.


5 District heating infeed with calorifier station. Right: refrigerating machine.

Heating

The entire building, except the inside rooms, is heated by radiators as before (*Fig. 4*). The existing installations could be retained for the most part.

The energy needed for room heating, ventilation, air conditioning and domestic hot water is obtained from the district heating system of the City of Berne via a new pipeline into the building. The existing boiler and oil tank installation was scrapped. The heating system designed by SULZER comprises the heating station with calorifier and distribution equipment, the connection to the municipal heating network, and the entire room heating. The connected heating load is 1330 kW (*Fig. 5*). Hot-water secondary circuits supply the room heating (radiators) and the air handling equipment, and heat the domestic hot water. On account of the great distances, the heat is supplied through three substations serving the main building, rear building and "Schütte" wing. The "Nägelistrasse" subsidiary building is supplied through an additional long-distance pipe branching off from the main building substation.

Air conditioning

The nature of the building and its purpose call for an adequate supply of conditioned outdoor air, with a total supply air rate up to 69000 m³/h. Not only the audience benefits from this, but also the actors and other theatre personnel. The different usages necessitated special know-how in the design stage. Very important also was economical use of energy. Optimal answers were arrived at by integral planning. Objectives for good air conditioning were:

- comfort in the auditorium with its geometry, acoustics and rapidly changing heat loads
- adequate airflow conditions assured in the stage shaft
- special demands satisfied in the subsidiary rooms (painters, tailoring, emergency generating sets).

Auditorium *(Figs. 2 and 3)*

The aesthetically valuable interior décor was to be preserved, nevertheless the room air flow and acoustics were to meet the higher standards set. A further difficulty was the stipulation that the system was to satisfy the required conditions in all operating modes (with curtain up and full house, reduced audience or various rehearsals).

Though the auditorium and the orchestra pit form a unit, they are served by separate air conditioning plants.

When no performance is in progress or during the preparation phase (preheating or precooling), the auditorium plant operates at reduced fan speed with energy-saving recirculation. During performances, it delivers 30 to 35 m³/h outdoor air per spectator, if necessary with heat recovery in addition.

For control purposes the auditorium is divided into four zones: pit, 1st, 2nd and 3rd circles. In each of these zones the air temperatures are detected by sensors in the backs of four chairs, at shoulder height. The measured air temperatures are averaged for each zone, then the air inlet temperatures are adapted within preset limits.

The outdoor air is taken in at roof level, ducted through a regenerative heat recovery system (*Fig. 6*) with up to 60% effectiveness, and conditioned in the central station in the 2nd basement. The supply air is led through four zone reheaters into plenum chambers below the four audience levels. It then passes without draughts through floor outlets under the seats straight into the auditorium (*Fig. 7*). These floor outlets were developed and produced using the SULZER heating and air conditioning test facility.

The exhaust air is extracted at the highest point, i.e. at the top of the ceiling (*Fig. 8*). If necessary, it is ducted through the heat recovery system and then discharged to atmosphere at roof level by the exhaust air fan.

In case of fire, the ventilation of the auditorium is shut down automatically. At the firefighting control cabinet, a smoke extraction system can be put into operation. The fire protection dampers in the annular exhaust air duct round the top of the ceiling are then opened, and a special smoke fan discharging about 30000 m³/h (*Fig. 8*) expels the smoke-laden air to atmosphere.

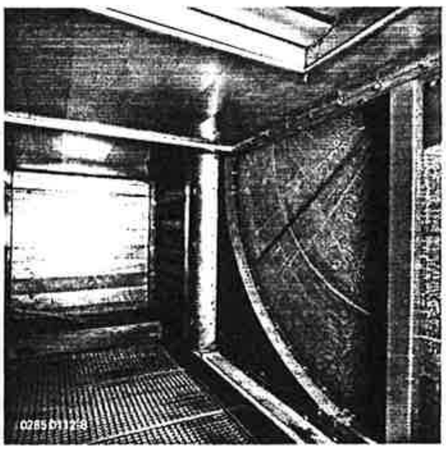
On the 2nd floor is the stage management and lighting control station. It is served by a separate air conditioning plant. The treated supply air is introduced through a double floor. The air is extracted through grilles in the ceiling.

The air for the orchestra pit is treated in its own air handling unit in the 2nd basement. Outdoor air is taken in at roof level on the south side. A fan delivers the conditioned supply air through two ducts to the plenum chambers at the back of the pit. Through special outlets the supply air is directed selectively and without draughts to the musicians' zone. The supply air temperature is kept within preset limits according to the average from two room sensors.

Stage shaft

The design of every theatre is influenced by its stage shaft. The one at Berne measures a respectable 26.5 m in height from the actual stage. A great deal of skill and experience was needed here to provide adequate ventilation.

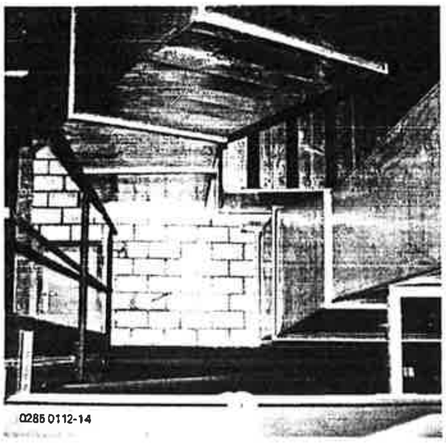
During the winter, in many theatres the cold air flooding over the orchestra pit and the front rows of the auditorium when the curtain is raised gives cause for complaint. Due to the usually large outside wall surfaces of the shaft, a strong downcurrent is liable to occur, which during cold spells may also chill



6 Regenerative heat recovery plant with grating over supply air duct (below), outdoor air bypass damper (behind) and air recirculation damper (above).

7 Seats with supply air admission through the floor.

8 Exhaust air duct in the dome above the auditorium, and smoke extraction fan.



9 Stage shaft ventilation plant with intake silencer, supply and exhaust air ducts.

10 Supply air duct at the stage shaft outside wall with air outlet openings directed upward.

11 Stage costume making in the attic.

the actors on the stage. Previously, attempts were made to counter this current by installing extra radiators up in the grid, mostly with unsatisfactory results. Coping with the cold downdraught is rendered even more difficult by working galleries, electric motors and lighting equipment.

A system had to be devised enabling the air currents to be mastered with minimum expenditure of energy so that they are no longer objectionable. This was accomplished with a special ventilation plant. The heated air due to lighting and other sources, which rises from the centre of the stage, is collected at the ceiling above the stage (*Fig. 9*). Depending on the temperature conditions, the plant operates with recirculation between 0 and 100%. The supply air is filtered, reheated if necessary, and discharged about 11 m above the stage through specially designed ducts and air outlets which direct it up along the stage walls. In this way the downcurrent is countered by the controlled warm air flow (*Fig. 10*). The ventilation plant is operated primarily with air recirculation. Heating is needed only if few or no heat sources are available. By exploiting the existing heat, the heating costs are lowered substantially compared with traditional technology. Moreover, with this ventilation concept, it is possible to obtain defined temperature conditions up in the grid zone.

For scavenging purposes or when smoke is generated on the stage, the ventilation plant can be operated for a limited time with 100% outdoor and exhaust air by pressing a special button on the stage director's panel.

Subsidiary rooms

The space underneath the stage is supplied by its own ventilation plant. The proportions of outdoor and recirculated air are varied according to the supply air demands, but there is always at least 20% outdoor air. Warm air from the upper part of the stage shaft is recirculated, resulting in optimal heat recovery. The air is distributed through a duct network and introduced through grilles.

Several workshops and property rooms are also connected to this air treatment plant.

The cloakrooms and the men's and women's stage costume-making have their own air systems (*Fig. 11*). Each of these is equipped with recuperative heat recovery (water/glycol system).

Further separate ventilation systems have been provided for the transformer, emergency power and battery rooms, also toilets.

Performance

Thanks to the careful planning and close cooperation of everyone involved, the work was completed to schedule. During their first duty spell (winter 1984/85), with its extreme weather conditions, the installations operated to complete satisfaction in every respect, and economically as well.

Bibliography

[1] Stadttheater Bern. Planen + Bauen, Zurich (1985), No. 3, pp. 49–54.

[2] Tschanz, P.: Stadttheater – Unser Theater. Edition Erpf, Berne (1984).