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New technical concepts for atria

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This report is the first in a series of technical papers by top E.

Optimized standards of use for the architecture of atria

In the search for an improved infrastructure in inner-city areas, building conceptions with halls, passages and air wells are enjoying a renaissance.

Among the most varied aspects such as the meeting area, lobby, climate absorber, improvement of micro-climate and so on, the architecture of the late seventies and eighties revealed the glass-covered room to be a special proposition with regard to space. According to utilisation requirements, there exist for objects to be built various solutions regarding technical equipment, whereby glass-covered sun rooms should not only be no more expensive, but at the same time they should also contribute to savings in energy and operating costs.

1. Specific standards of use determine innovative solutions

An essential aspect of building structures with glazed halls is the protection of working space against the outside. In inner-city areas there are a multitude of emissions which can reduce the comfort of a building to a considerable extent. Thus it is possible to develop a building integrally under the catchphrase „Form follows comfort", whereby the technical aspects also occupy a prominent place.

1.1 The protection of office space against emissions

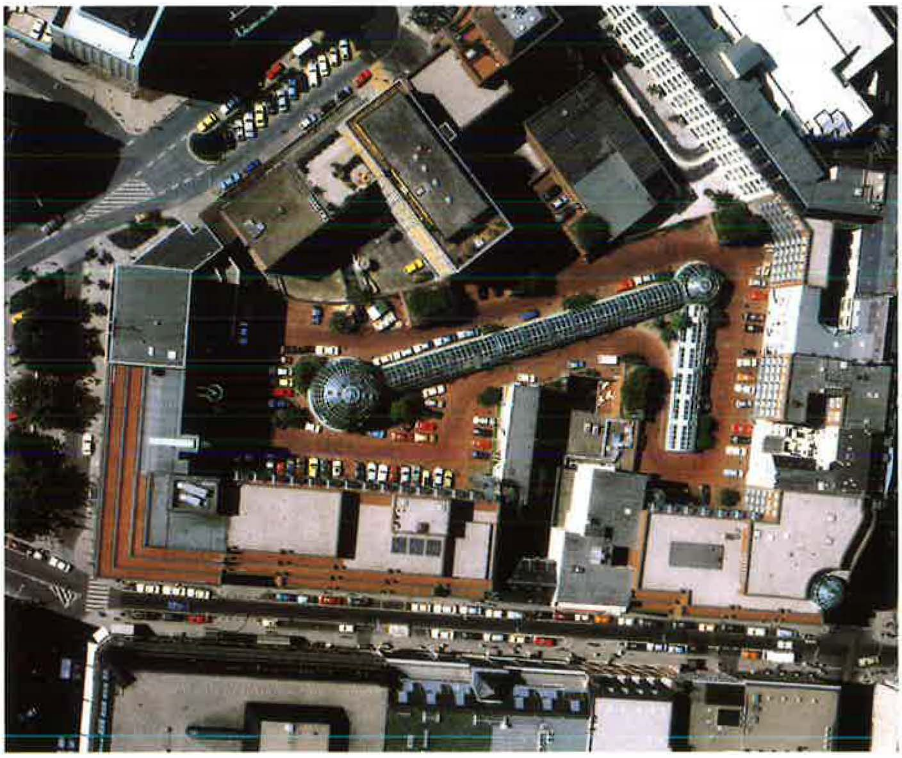
In inner-city areas there are generally emissions in the form of noise, dust and exhaust fumes which one tries to a large extent to combat in order to prevent a reduction in the comfort of the working space.

Picture 1 is a photograph of the new technical centre of the Stadtsparkasse in München. This building was built in the immediate vicinity of congested streets. The architects developed a design concept in which protection against noise is effected by high glass walls. The client's usage requirements were in consequence aiming simply in this direction, whereby greenery laid out in open inner courts should contribute to the improvement of the micro-climate during the transitional seasons and summertime.

Picture 1 Stadtsparkasse München (Arch.: Kochta,Obersteiner)

1.2 Improvement of the spatial ambience by means of evergreen gardens

Picture 2 DAK Hamburg (Arch.: Pysall, Stahrenberg + Partner)



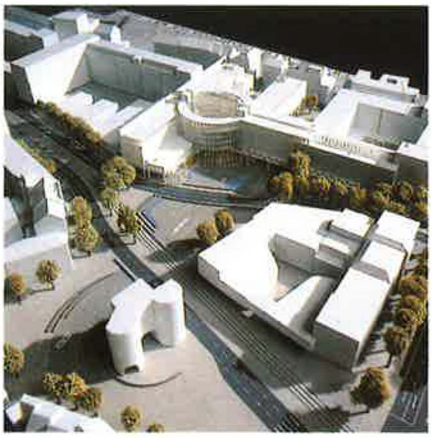
Picture 3 Hanse Viertel, Hamburg (Arch.: v.Gerkan•Marg + Partner)

Picture 2 is the photograph of a model of the building project of the Deutsche Angestellten-Krankenkasse in Hamburg. In this project the architects have developed a building configuration with partially and temporarily closed conservatories or conservatories which partially protect the office rooms from the external environment against emissions like noise, dust etc. In contrast to the project of the Stadtsparkasse in München, however, the conservatories should bring about an extensive improvement in the micro-climate by means of plants in winter as well. This means that the conservatories only need to be minimally heated during the cold season.

1.3 Public resting and traffic zones under protective roofs

In order to be able to present a spatially attractive offer, inviting people to rest a while, halls and passages have been conceived for the project presented below. In the project Hanse Viertel, Hamburg, shown in **picture 3**, passages and court situations were constructed which are heated minimally and indirectly from the adjoining shop fronts in winter or are minimally and indirectly cooled by the corresponding areas in summer (cooling by return air flows). This solution has proven its worth through many years of use, and has led to the acceptance of this offer by the general public.

Picture 4 is a photograph of a model of the project of the Stadtsparkasse in Köln which is still under construction. A large glass-covered rotunda with glass-covered passages provides for a protective wall which equally invites people to rest a while. As with the project of the Hanse Viertel in Hamburg direct ventilation or cooling is not planned, but the rotunda will simply be heated up to approx. 7 °C - 10 °C in order to offer an agreeable comfort. Furthermore, as with the Hanse Viertel in Hamburg, a natural ventilation in transitional seasons and in summer is provided by glass openings.



Picture 4 Stadtsparkasse Köln (Arch.: HPP Hentrich-Petschnigg + Partner KG)

1.4 Public meeting halls

In the town hall in Unna which was completed some time ago, a planning idea was pursued in such a way that a public meeting room surrounded by office

Picture 5 Rathaus Unna (Arch.: D.Kälberer)

areas (town hall) and covered with glass surfaces is created in which the widest variety of activities can take place.
A requirement with regard to definite room temperatures did not exist for this hall, with the result that it does not have any technical installations and is heated in winter merely in an indirect way by the adjoining office areas (loss of heat through windows and walls).

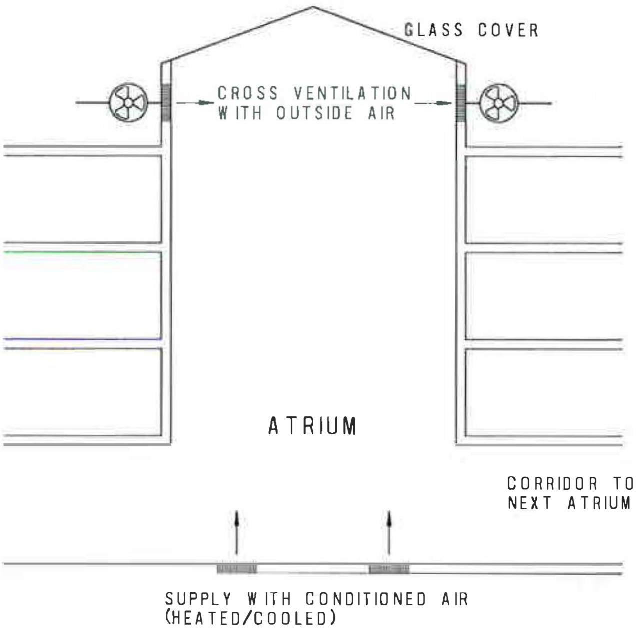
1.5 Internal resting and traffic zones under glass

In the project shown in **picture 6** of the Landeszentralbank in Frankfurt am Main, a resting and traffic zone was conceived which connects the floors from the 1st to the 3rd upper storey. In contrast to all the other projects mentioned up to now, the inner hall is protected against external emissions by a double glass roof. The correct temperature in the hall is achieved via return air flows through the double glazing in order to bring the room and surface temperature in winter up to approx. + 20 °C. The requirements of the client were such that the hall should be naturally illuminated and that as a resting zone for the staff the temperature should be within a range that a longer stay is possible under comfortable conditions.
Another example is the Shell Central office in The Hague. It is one of the twin central offices of the Royal Dutch/Shell Oil Company. The old office, dating from 1917, was enlarged with about 33,000 m^2 in 1986. The newer part is constructed around four atria (one of them joining the old and the new part), as a modern counterpart to the open inner courts of the old building. All four atria are connected by an open corridor.

The other atria, covering four floors, have no special meeting functions, but are respectively used as exposition room and indoor garden.

Picture 6

Landeszentralbank Frankfurt (Arch.: PAS Prof. Jourdan Müller Albrecht with Berghof Landes Rang)



Picture 7 Royal Dutch/Shell Diagramm Cross Section of Atrium

Picture 8   Royal Dutch/Shell Atrium

Climatization is realized by an all air system. The air is supplied via floor inlets, and is extracted at the ceiling level of the atrium.
(Pictures 7 + 8)

The supply air to the inhabited zones can be afterheated, to obtain a suitable micro-climate here. No floor or radiant heating is needed.
At warmer conditions, a cross flow at the ceiling prevents unwanted heat accumulation in the atrium. In the central atrium a double, semi-opaque ceiling is used. Cross flow is between the ceiling levels. Because of the semi-opacity, the ceiling can be used for some duct crossings, while the daylight effect is still acceptable.

Aegon is an internationally operating Dutch insurance company. The office was completed in 1989. The atrium has functions as reception and time registration desk and has a special attraction by means of a big wall painting.
The atrium covers three floors, with open corridors crossing the room, providing a spatial effect. The atrium has not an opaque ceiling, daylight enters via windows over the heighest two floors, and enters the atrium partly at the rear side of the corridors, giving the impression of a vertical light beam. **(Picture 9)**

Picture 8 Royal Dutch/Shell Atrium

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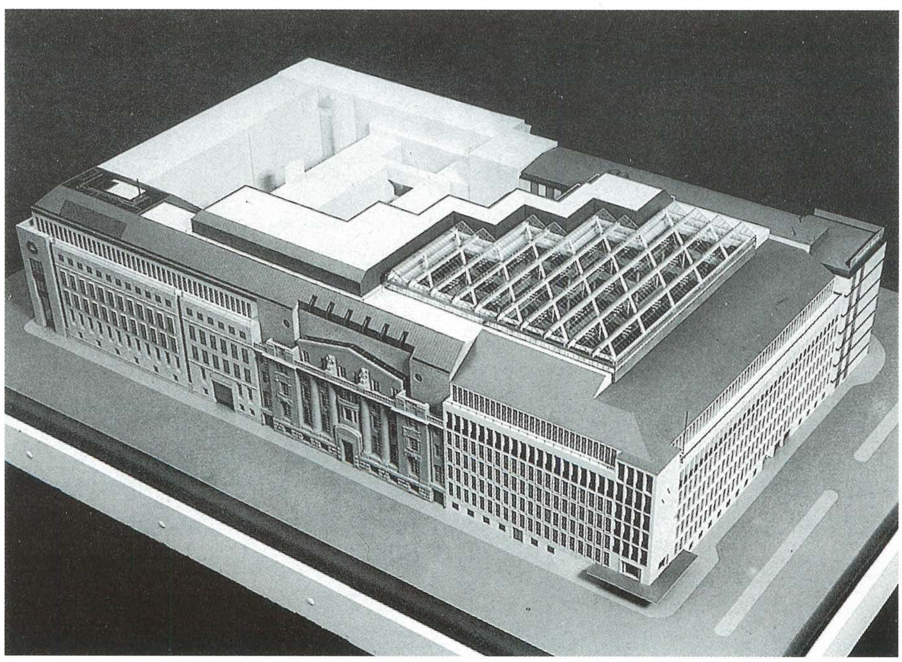
1.6 Public and internal utilisation in atria

Picture 9 Aegon Insurance Leeuwarden Atrium

In the following projects, the Dresdner Bank AG in Düsseldorf and the new Customer Service Centre of Frankfurt's District Energy Supply, the clients' usage requirements were that the respective halls should serve as usable areas so that people could stay there continuously. For this reason room temperatures of about + 22 °C in winter and in transitional seasons, up to maximum room temperatures of approx. + 26 °C to + 27 °C in summer had to be achieved.

The absence of an opaque ceiling avoids many technical problems resulting in simple technical installations. A good room comfort is realized without floor heating and with only air supply via ceiling outlets.



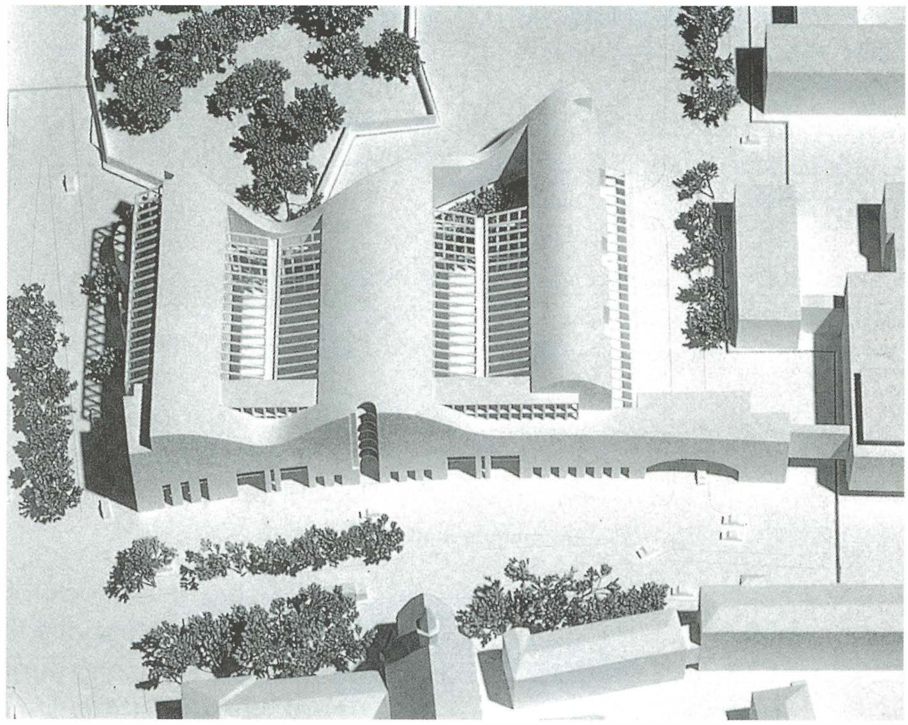
Picture 10 Dresdner Bank Düsseldorf (Arch.: Krämer, Sieverts + Partner)

In the project of the Dresdner Bank Düsseldorf shown in **picture 10**, there is no natural ventilation through the glass surfaces; the hall is ventilated partly in a direct and partly in an indirect way.

The project of Frankfurt's District Energy Supply, shown in **picture 11**, also includes a partially direct ventilation of the customers' hall and the large canteen so that comfortable room conditions are created in the hall.

According to the usage requirements, architectural concept and spatial conditions for atria and similar areas will consequently be either:

- naturally ventilated
- naturally ventilated and minimally heated
- naturally ventilated and indirectly heated
- indirectly ventilated (recirculation of return air streams)
- directly ventilated, heated and cooled



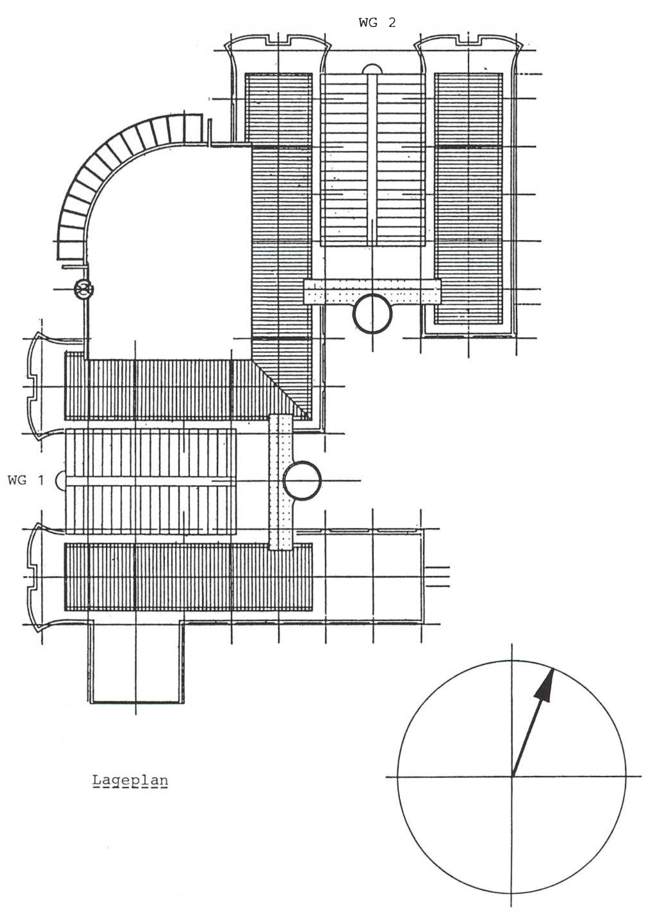
Picture 11 Stadtwerke Frankfurt (Arch.: Gisel, Zürich)

Whether and in which form the heating or ventilation of atria will occur therefore depends exclusively on the usage requirements. However, there should be a common demand for all solutions that technical installations are to be minimized as much as possible and that the architecture is affected as little as possible.

2. The atrium as a protective foyer in office buildings

Halls, in the sense of lobbies, often serve as protective foyers for office buildings. Nevertheless, they can also serve for some additional purposes in which people stay constantly. According to the demands and usage requirements, there are greatly differing approaches to technical solutions.
By means of some selected examples that appear below, the different possibilities are illustrated.

Picture 12 shows a footprint of the building with the planned conservatories.



Picture 12 DAK Footprint with Conservatories

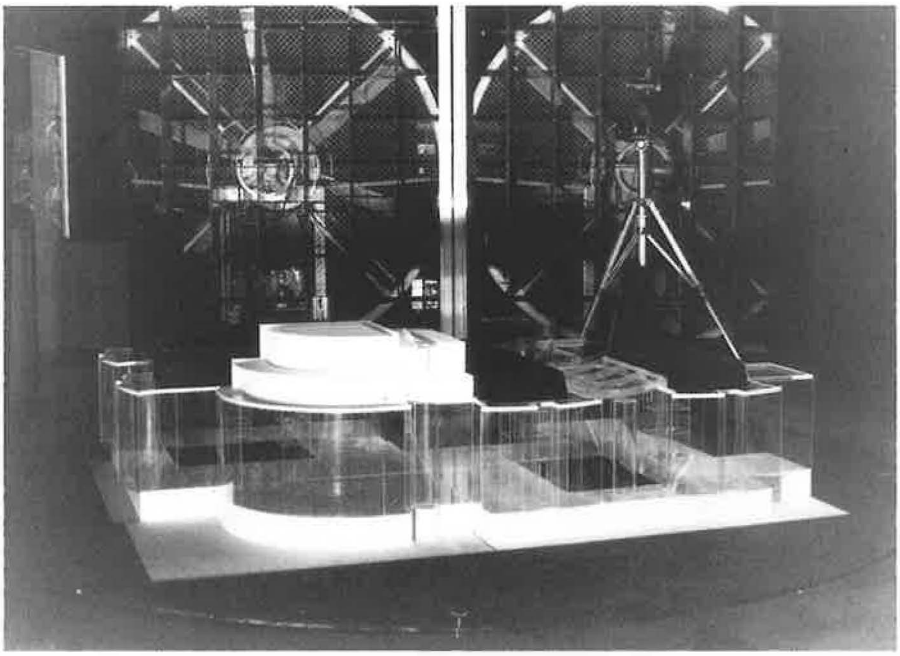
2.1 Naturally ventilated foyers

Using the example of the project of the Deutsche Angestellten-Krankenkasse, a short explanation is given as to which technical measures were necessary to satisfy the requirement of a naturally ventilated office building behind the conservatories.

The requirements of the owner and architects were that the conservatories should be naturally ventilated to the greatest possible extent and that natural ventilation of the offices should be provided for the conservatories.
Only in winter should the conservatories be minimally heated so that the greenery will survive to contribute to the improvement of the micro-climate. In order to ascertain whether and in which form the office rooms adjoining the hall are receiving sufficient natural ventilation, it is necessary to carry out a model simulation in the wind tunnel.
By means of an appropriate model simulation, it can be ascertained with sufficient accuracy in the planning

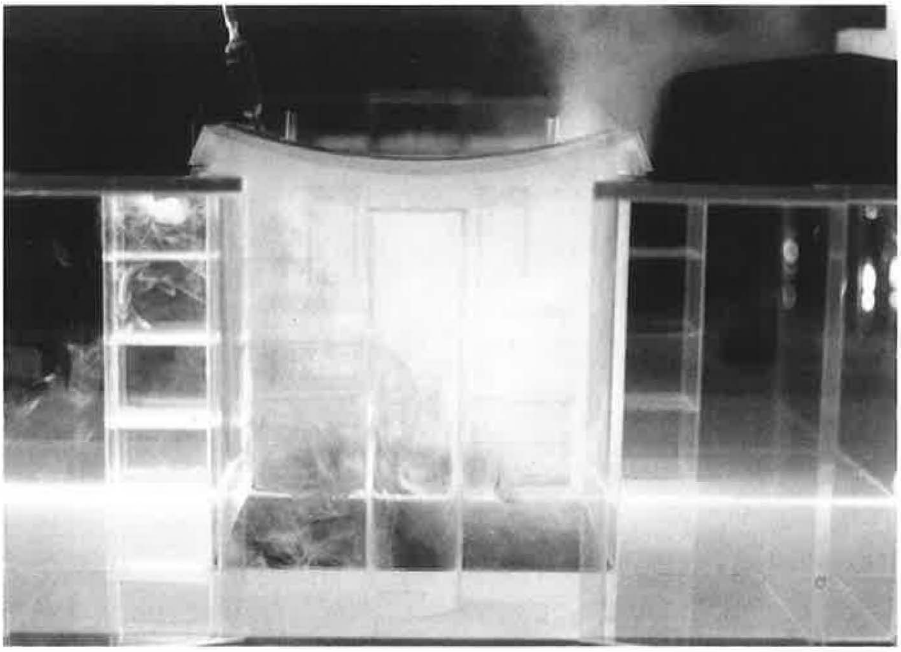
phase how many air changes enter both the hall and the office rooms when the corresponding glass surfaces are opened.

Picture 13 shows the wind tunnel of the company Keßler Luch with the fitted model of the DAK. During the wind tunnel experiments (incident flow of the model with different wind speeds and directions),the air currents which are created are made visible by means of smoke.



Picture 13 Mock-up in Wind Tunnel

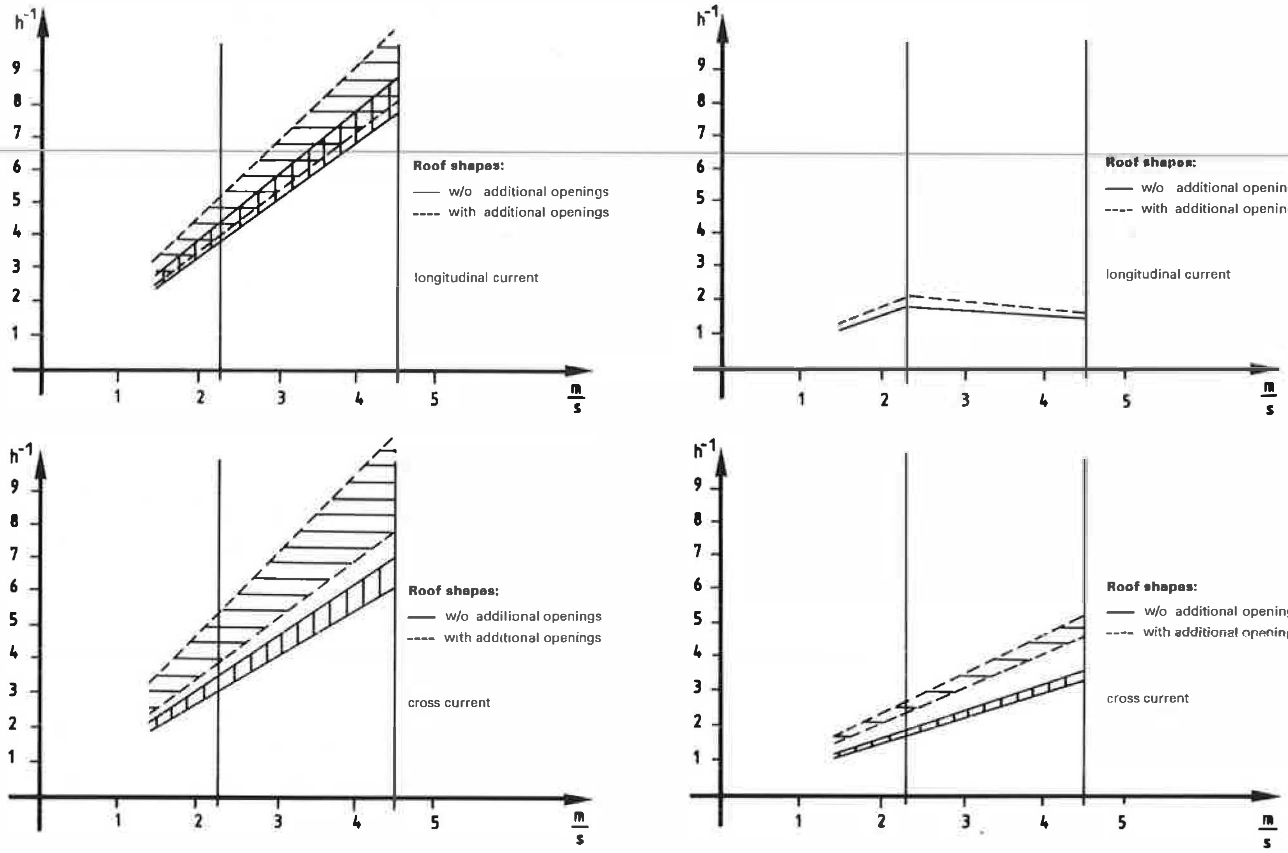
Picture 14 is a corresponding picture of a conservatory with air flows made visible by means of smoke.The qualitative assessment of the model's throughflow leads the planner to the first conclusions whereby demands are made on the architect to the same extent as the building service consultant,since the natural ventilation for an atrium via roof and windows surfaces has to be designed jointly and can lead to totally different solutions from case to case.



Picture 14 Ventilation Test with Smoke

The quantitative assessment of the numbers of air changes and also for the guarantee of minimal outside air flows according to the guidelines of workplace, occurs in a corresponding model by which concentration measurements are taken over a period of time by means of laughing gas, for example. These measurements supply in turn information about corresponding air changes. With reference to the example of the DAK project, the following diagrams in **picture 15** show the determined number of air changes both in the conservatories as well as in the adjoining office rooms on the basis of corresponding gas analyses.

Depending on the location of the building there are more or less days with lulls (2-10 % of all days) when halls are ventilated by thermal air currents. For this, a computer simulation will be necessary as a hall should evidently not become a „hothouse" behind which the office rooms heat up even more as a result of indirect radiation, internal heat sources and so on. A special problem of conservatories is that the methods of calculation are still at an initial stage with regard to the heat withdrawal due to evaporation. This is because the greenery planners have



Picture 15 Air Change Rates in the Conservatory

Air Change Rates in the Offices

relatively little knowledge with regard to absorbed and evaporated water quantities.

Picture 16 shows by example two temperature examinations of differently orientated conservatories; taking account of no planting or intensive greenery respectively.

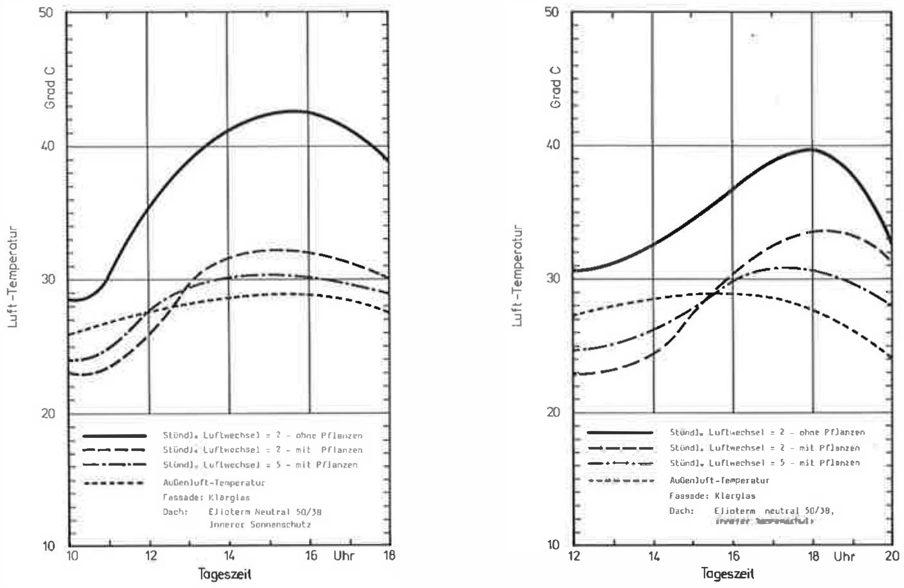
As shown in the diagrams, the use of greenery can bring about considerable temperature reductions, and, if the situation arises, these may even be necessary according to the utilisation requirements.

1. Supply air opening at the end wall approx. 15 m^3 (net) for lulls (thermal ventilation)

2. Outlet air opening / supply air opening about 45 m^3 (gross)

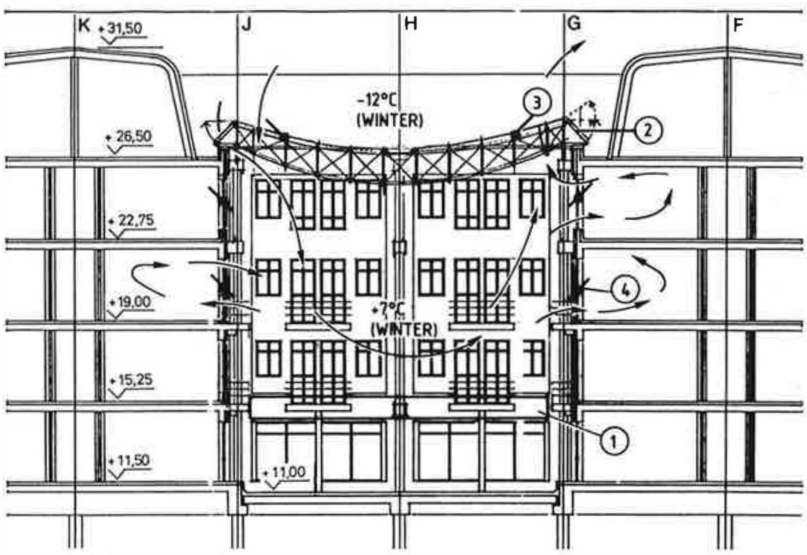
3. Outlet air opening / supply air opening about 40 m^3 (gross)

4. Swing window for gathering natural air currents.



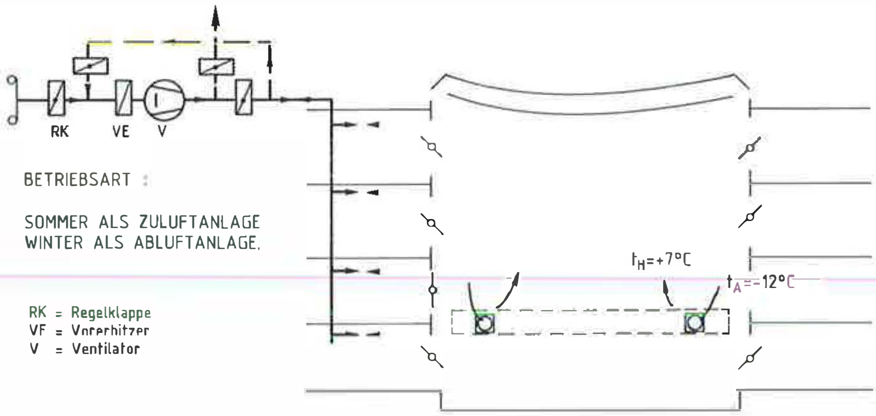
Simulierte mittl.Lufttemperatur im Grünhaus - Juli (heiter) Himmelsrichtung SW - NW

Picture 16 Temperature Simulation in Conservatories



Picture 17 Technical Measures for Natural Ventilation

In the case of the DAK, as well as in the structural engineering domain as in the services domain, measures will be necessary for heating of the hall in winter and for the directed hygienic ventilation of the office rooms adjoining the hall (these are demonstrated in **pictures 17 and 18**). As a result of all examinations, a system solution has finally been conceived whereby once correctly positioned, supply and exhaust air openings in the glass surfaces and, furthermore a very simple ventilation system which ventilates or air-conditions the office rooms mechanically according to the season, will be necessary. The conservatory will in winter reach a room temperature of + 7 °C in order to maintain the user's requirements.



Picture 18 Ventilation for Precooling of Offices (Summer) or Evacuation on Lull Days

Picture 19 SFS Stadler Heerbrugg AG (Arch.: Rausch, Ladner, Clerici)

Picture 20 Glass-covered Hall

2.2 Foyers with indirect mechanical ventilation

By means of the project for the company SFS Stadler a building is presented in which a hall foyer will connect office areas with one another in an open method of construction.

Picture 19 shows the building, **picture 20** the glass-covered hall with the adjoining office rooms.

In this project the hall serves as a circulation and exhibition area and will be heated only in the roof area during the winter by electric heating wires so that no cold air drops will occur, thereby causing draughts in the floor area.

Furthermore, during the transitional seasons and the summer, the roof surface can be opened mechanically by about 10 % in order to achieve a natural ventilation of the hall space and, in case of fire, to allow the smoke to draw off. With regard to the hall itself, the client required only that this should be suitable for a circulation and exhibition area, but not constantly. In this respect, a hall temperature of approx. + 15 °C in winter is adequate. This temperature will be achieved, as already described, by means of heating wires (Raychem System) which is integrated in the steel construction of the hall roof.

The office rooms adjacent to the hall will sometimes be ventilated by exclusively natural means, sometimes the ventilation and cooling will be used if the outside temperatures are too high in summer or if, because of strong winds (over 5 m/sec) a draught free natural ventilation is difficult to achieve. **Picture 21** shows part of an office area adjoining the corresponding hall space.

As the hall does not serve as an area where people stay constantly, direct ventilation or even air-conditioning is not necessary, except heating in winter in order to prevent cold air flows due to glass roof temperatures which are too low.

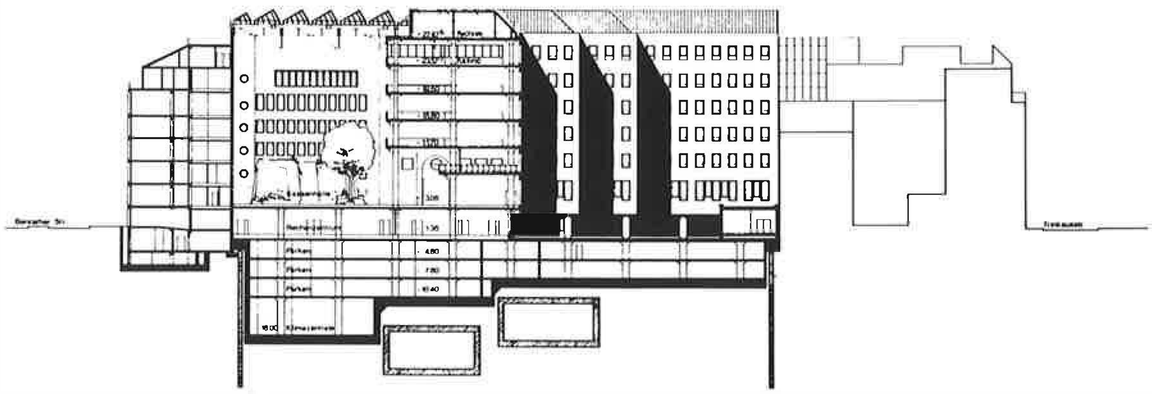
Picture 21 SFS Office Space

Picture 22 Inside View of Banking Hall

2.3 Partially air-conditioned atrium as used area

If hall spaces are to be used as protective foyers and are to serve as areas where people stay constantly, the technical measures have to be extended. **Picture 22** shows the hall of the Dresdner Bank which serves as a counter and customer hall and lies below a glass surface which covers the complete hall space at the 7th upper floor level.

Due to the extraordinarily large room volume in proportion to the populated area on the ground floor, a direct ventilation of the hall in the floor area or of the working areas would not in itself be necessary as people would be provided with sufficient outside air. However, one has to consider that in the case of complaints, the requirements of the workplace guidelines have to be observed such as there have to be at least 6 m^3/m^2 h outside air.



Picture 23 Section through Hall

In the case of the Dresdner Bank a floor installation was designed to provide the necessary quantity of outside air flow into the corresponding areas via floor outlets. The amount of heat in the hall caused by solar gain and convective heat is mainly compensated by the extract air flow from the adjoining office areas so that the quantity of air that is directly brought into the hall does not require cooling. Whereas only approx. 8,000 m^3/h of outside air is blown into the floor area, about 80, 000 m^3/h of used air which comes mainly from the adjoining office rooms in the upper storeys is extracted from the hall. By these means the technical effort for the warming and ventilation of the hall is minimized. Moreover, the air which is extracted serves to screen off the cold glass surfaces in winter when minimal outside temperatures prevail.

Picture 24 Hall Seen from Upper Floor

Picture 23 shows a sectional view of the hall to illustrate the relative sizes, **picture 24** a view of the construction of the glass roofs with hollow beams serving also as air ducts for the warming of the glass surfaces in winter. The warming of the glass surfaces in winter is necessary to prevent thermally rising air flows becoming so extremely cooled at the glass surfaces that they flow down to the floor area in the form of quickly circulating cold air currents and cause considerable draughts.

3. Minimizing technical installations for atria

The minimizing of technical installations for atria is normally only possible with co-operation between the client, architect and services engineer. With a great deal of imagination and, if necessary, reductions of comfort, one can find very simple and straight- forward solutions in order to construct halls according to the usage requirements with a minimum of technical effort.

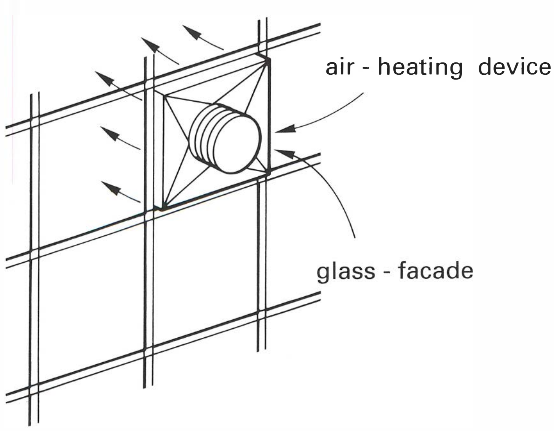
3.1 Conservatories
- winter heating
- natural ventilation in summer

It has already been indicated in the DAK building project that winter heating will be necessary in order to achieve a minimal room temperature of about + 7 °C.

After discussion with the architect, he proposed direct heating through standardized warm air heating blowers installed in the front wall.

Picture 25 is a schematic demonstration of the installation of the corresponding units. In order to bring a quantity of 6 m^3/m^2 h of outside air to the office rooms to improve the hygienic conditions on days without wind, an installation has been conceived which exhausts the corresponding office rooms, whereby the supply air flows from outside via the hall into the office rooms. By means of switching blades, this exhaust air installation can also be used in summer for the pre-cooling of the building during the night.

The air flow is reversed and leads cold outside air through the office rooms and lets it enter into the hall (compare **picture 25**). Using an open ceiling construction, the concrete ceilings are decharged by the cool outside air so that they possess a storage capacity for the next day (warm summer day). During the day, they can absorb a part of the excess heat, causing the room temperatures not to rise too high. After passing the rooms, the cool night air is expelled once again into the open via the hall. This example shows that a range of demands can be met by minimal technical efforts, whereby the heating of the hall in winter would also be possible by means of perimeter heating (water, electricity).

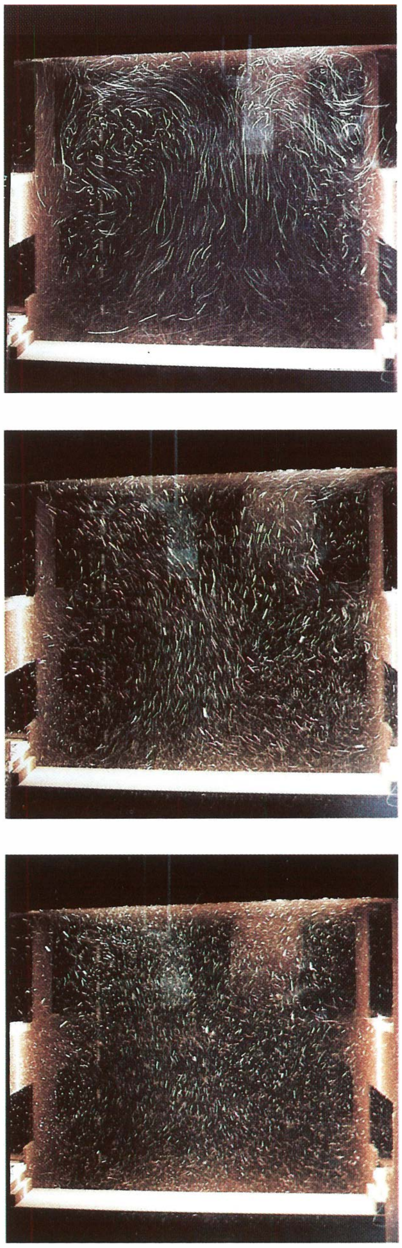


Picture 25 Air-heating Device (Facade Mounted)

3.2 Direct and indirect heating

If atria are to serve as areas where people stay constantly (resting zones/office areas), one has to take care that the cold glass surfaces do not lead to unpleasant cold air circulations and consequently to the occurence of draughts. **Picture 26** shows three presentations of air currents with flakes (split-second photographs) which were made in the course of the planning of the LZB project in Frankfurt.

When there are temperature differences of more than 4 K (°C) between the room temperature (the internal hall temperature) and the glass surface temperature cold air currents occur. Due to the fast circulation, the cold air currents enter the floor area and this leads to draughts. The danger of draughts is only averted if the difference in temperature is not more than 4 K.



The pictures show room currents made visible by flakes and with glass surface temperatures of

10 K under room temp.

7 K under room temp.

4 K under room temp.

Picture 26 Cold air circulation caused by cold roof surfaces.

The warming of the glass surfaces (horizontally and vertically) can be effected either directly or indirectly. A direct warming of glass surfaces can be achieved by:

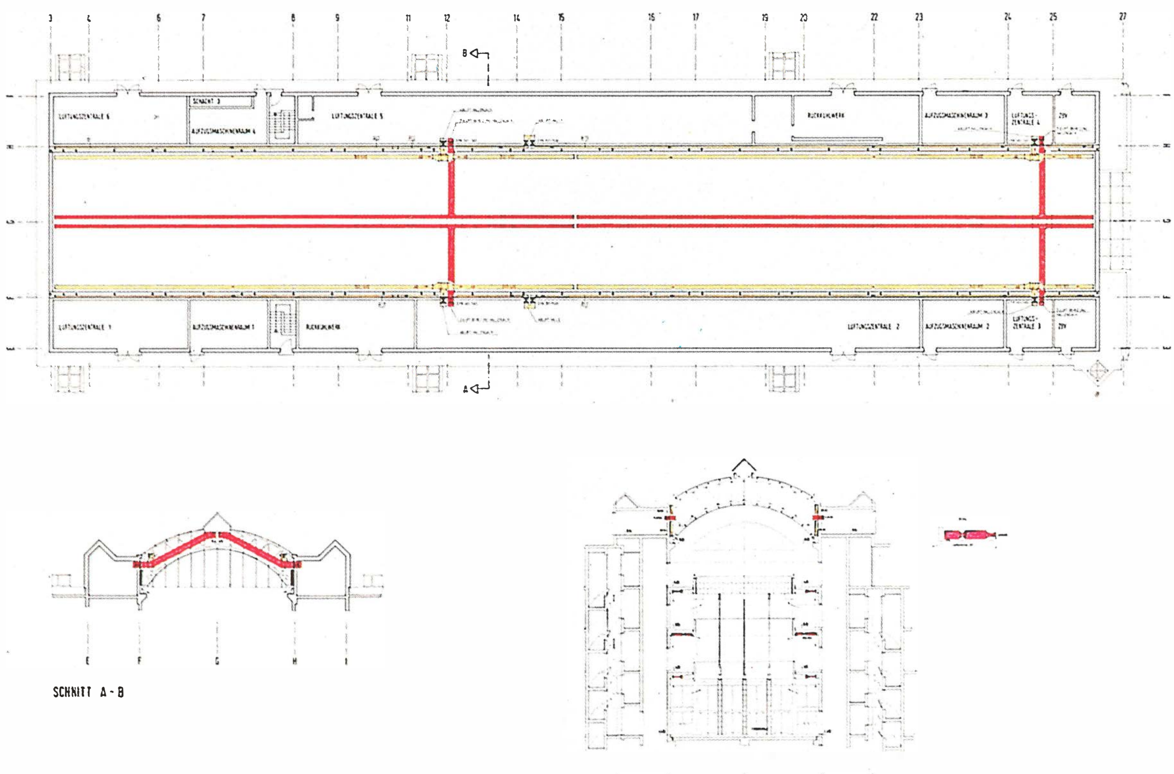
- heating of perimeter by electrical resistance wires
- heating of perimeter by warm water
- heating of the glass surfaces by warm air

According to the type of the desired glass roof construction, one of the afore-mentioned solutions will be used, whereby **picture 26** demonstrates a direct heating through the building's used air currents for the project of the Landeszentralbank.

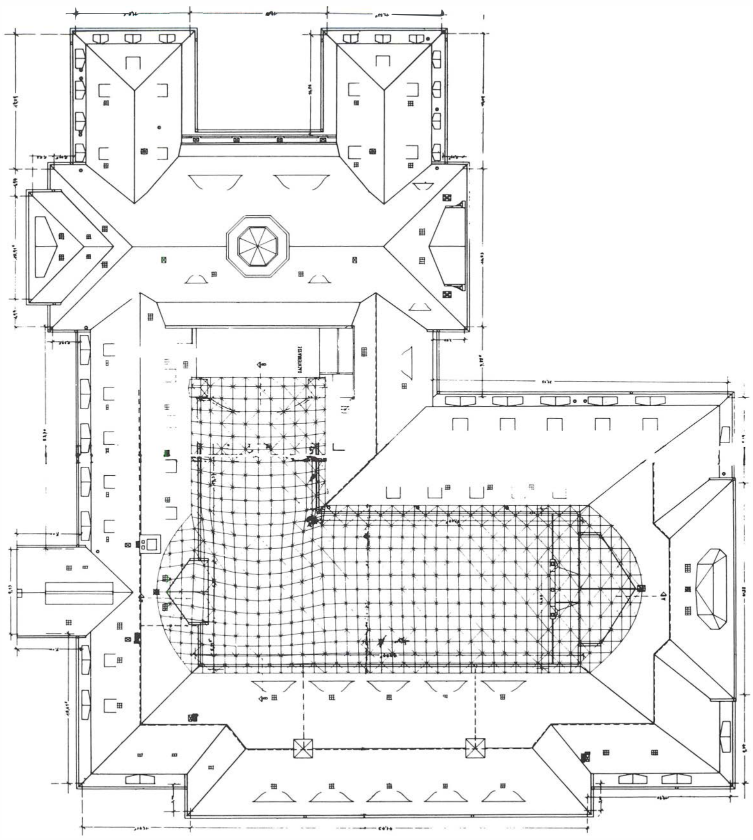
Pictures 28 to 30 show the freedom of architectural design and construction at the "Museum für Hamburgische Geschichte" in Hamburg. This superlight roof structure with single glazing is heated by electric wires. Thus condensation can be avoided and the courtyard temperature can be kept above 10 °C to protect the exhibited parts.

An indirect heating occurs if the heating of glass surfaces is possible through unprocessed exhaust air flows.

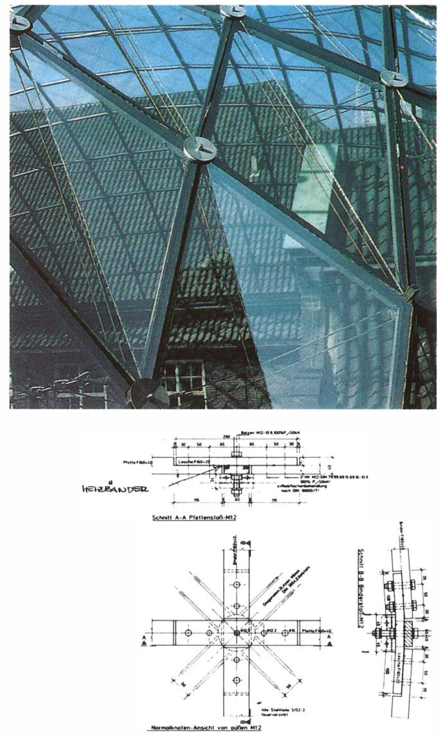
Whether and to what extent heating has to be effected mainly depends on the usage requirements (internal hall temperatures) and the transmission of the glass hall itself. When low hall temperatures are set (e. g. 7 °C) and the glass surfaces are well thermally insulated, one can under certain circumstances manage without direct or indirect heating of the exposed surfaces.



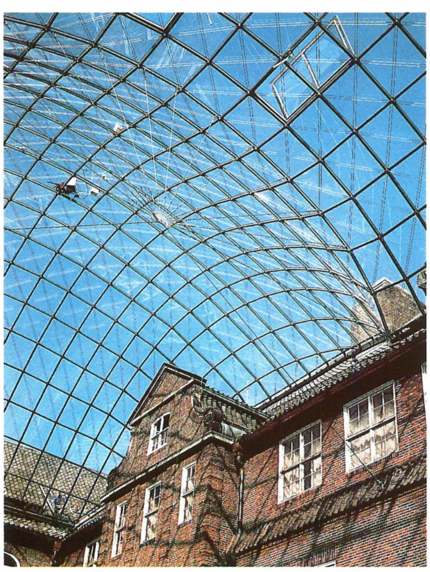
Picture 27   Installation of Hall Ventilation (Plan view and Section)



Picture 28 Museum für Hamburgische Geschichte (Arch.: v.Gerkan•Marg + Partner)



Picture 30 Detail of Roof With Electric Heating



Picture 29 View of Glazed Roof

3.3 Indirect ventilation and cooling

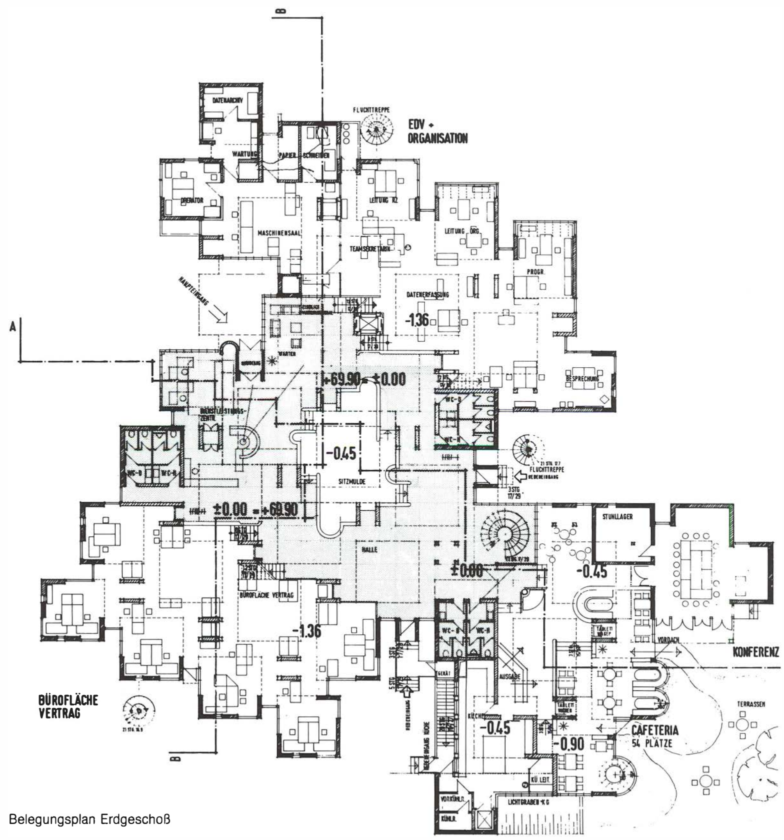
As in the LZB building project, ventilation and cooling of the office areas is effected as needed in summer (i. e. for outside temperatures of more than 20 °C) , and at the same time exhaust air currents are extracted through the roof area of the hall. This also results in an indirect ventilation and cooling of the hall space. Due to the special hall construction of the LZB - double glass roof - only diffuse sunlight enters through the latter, leading to an increase in temperature on each floor of about 1 to 1.5 K. In the sense of minimizing the technical equipment, it has to be established in each case whether the necessary air quantities in a building complex can be drawn off through the hall in such a way that it will be indirectly ventilated, and, if necessary, cooled without having to install separate equipment for the hall itself.

3.4 Direct ventilation and cooling

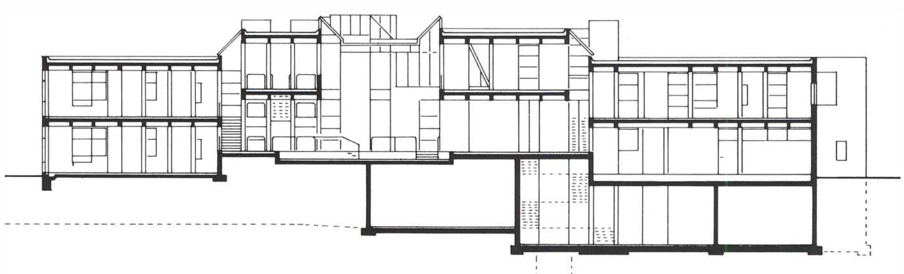
Direct ventilation and, if necessary, cooling of the halls will be required if the latter are to serve as areas where people stay constantly. At the same time one has to take care that in the sense of minimizing the technical installations, only those areas which are used will actually be ventilated.

For example, in a large entrance hall only the gate keeper's area can be ventilated via a double floor or suitable air outlets in the working area. Thus the rest of the atrium needs not to be ventilated.

Picture 31 shows a ground plan of the „Außenwerbungskontor", Koblenz with a solution for the hall and surrounding open office areas. **Picture 32** is a sectional drawing of the hall with the adjoining split level surfaces.



Picture 31 AWK, Koblenz (Arch.: Kersten, Martinoff, Struhk)



Picture 32 Section

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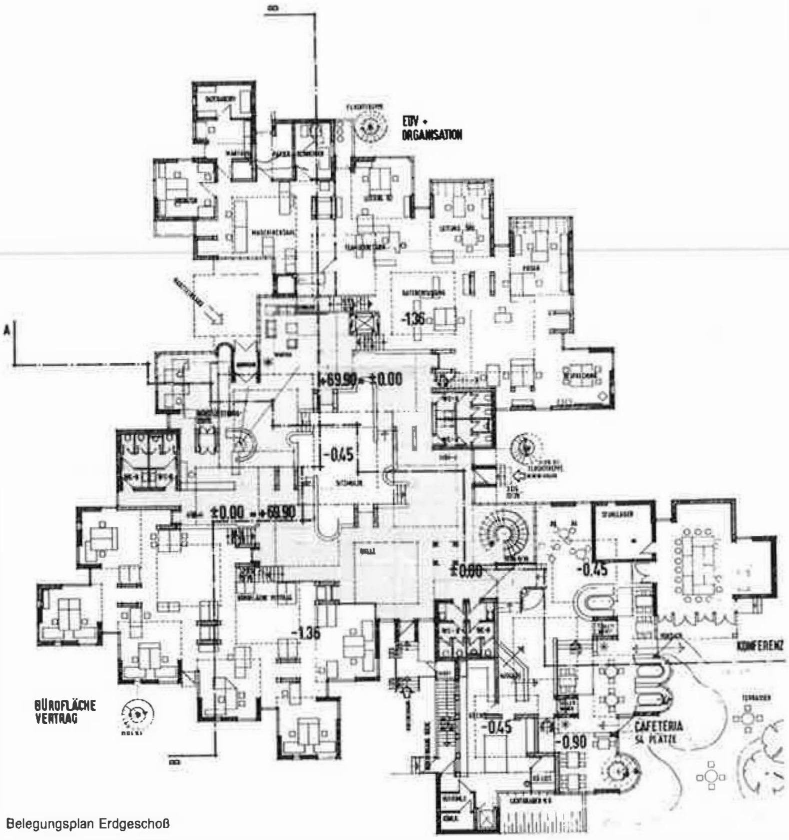
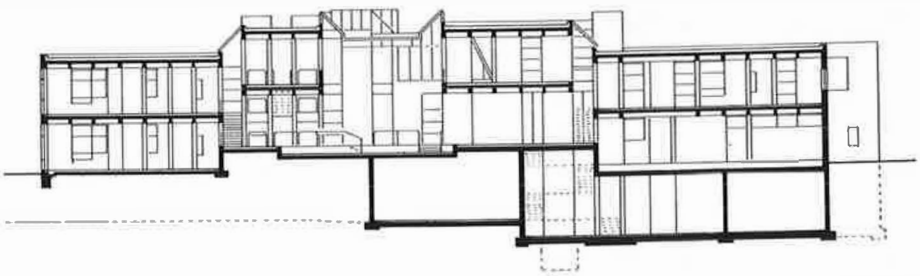
For example, in a large entrance hall only the gate keeper's area can be ventilated via a double floor or suitable air outlets in the working area. Thus the rest of the atrium needs not to be ventilated.

Picture 31 shows a ground plan of the „Außenwerbungskontor", Koblenz with a solution for the hall and surrounding open office areas. **Picture 32** is a sectional drawing of the hall with the adjoining split level surfaces.



Picture 31 AWK, Koblenz (Arch.: Kersten, Martinoff, Struhk)



Picture 32 Section

Picture 33 Central Hall

For this office building direct ventilation and cooling has been designed with a single central supply air outlet in the hall area (**picture 33**) which blows in the quantity of air corresponding to one-fold air change. This allows supplied air to flow through the office rooms according to the principle of replacement ventilation whereby it is minimally cooled. A compensation of sun radiation and inner heat sources with only one-fold air change is a novelty in itself and can obviously not be compared to air-conditioning. However, the latter was not desired for this building so a minimization of technical installations was possible.

As has been proved in the meantime after the use of the building over many years, a maximum permitted room temperature of about + 30 °C will be reached only on very few days during the year and the users have hitherto described the hygienic comfort as sufficient. Direct ventilation and cooling has also already been demonstrated by the example of the Dresdner Bank and can in practice be planned for any building where the hall is not as a whole taken as a room where airconditioning is to be used. It is essential only that one in fact concentrates on the corresponding working areas or the number of people and ensures that the temperatures required by the workplace guidelines prevail.

Another example of direct heating with a minimum of hall ventilation is that of the „Schweizerischer Bankverein", Basel (**picture 34**). The hall serves as a central entrance area for two building complexes and is heated in winter by warm water profiles and floor heating and minimally ventilated in bridge areas.

Picture 34 Schweizerischer Bankverein,Basel (Arch.: Burckhardt+Partner AG)

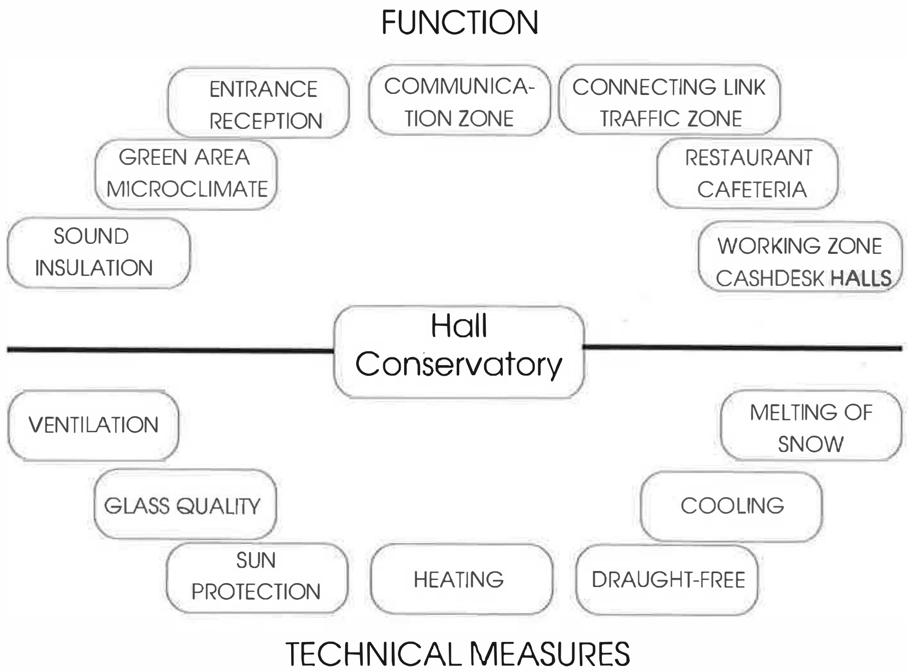
Pictures 35 and 36 are indoor photographs of the hall. These show that the technical installations are integrated in such a way that they do not attract the attention of the viewer.

Picture 35 Inside View of Hall

Picture 36 Roof Construction

4. Summary

By way of a summary, we would like to indicate the connections between function and technology in **picture 37**:



As the illustration shows, a number of requirements and functions very frequently result in solutions for halls or conservatories. According to the function and usage requirements, there are demands concerning ventilation and glass quality etc. In each case, therefore, one has to develop a special technical conception considering the structural measures, whereby points of emphasis lie in the domain of technical measures (lower running costs and maintenance charges).
In the ideal case a solution for a hall should at least be no more expensive than a comparable solution for an open court and should at the same time lead to lower operating costs.