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AIR DISTRIBUTION IN INDUSTRIAL HALLS

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SUMMARY

Key elements in air ventilation plants are the air outlets. The selection and the layout of the outlets are major factors influencing the quality of the air conditions. In industrial halls they also affect the quality of the products, production performance and pollutant concentration in the hall.

The major features of air outlets are the degree of turbulence, adjustability of the air flow and the position of the air inlets in the room. In halls where there is a significant level of pollution, low turbulence air jets are used and turbulent jets ar employed in halls with negligible pollution. In halls with high specific heat loads, it is better to discharge the supply air at floor level. In the case of low heat load, the supply air can also be discharged above the occupied zone. With high heat load fluctuation and considerable discharge heights, air outlets should be installed whose direction of air flow can be adjusted.

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INTRODUCTION

Indoor air conditions are to be kept within comfortable limits with the supply air which is blown into the room through the ventilating and air-conditioning plant. These should be understood primarily to be an adequate supply of fresh air, a suitable room temperature and possibly a desired range of indoor air humidity. Furthermore, harmful substances produced in the room should be effectively extracted. This final aspect is particularly important in industrial plants.

This task should be carried out by the supply air with no undesired side-effects such as draughts or a high noise level.

The effect of the supply air introduced depends to a large extent on the place of introduction and the degree of turbulence in the air jets.

There are three important parameters for the choice and design of the air outlets:

Type of air flow:
turbulent or low turbulence

Position of air supply:
- from the ceiling
- from the walls
- from the floor or from tables

Adjustability of the direction of air flow
- constant direction of air flow
- adjustable direction of air flow

TYPE OF AIR FLOW

According to the degree of turbulence one can differentiate between turbulent and low turbulence air jets. Turbulent air jets have a higher induction effect and mix more thoroughly with the room air. They create an induction with a rarefying effect. The low turbulence air jets have a lower induction effect and do not mix as thoroughly with the room air. The spent room air is displaced more than it is mixed. This is called a displacement air flow (Figure 1).

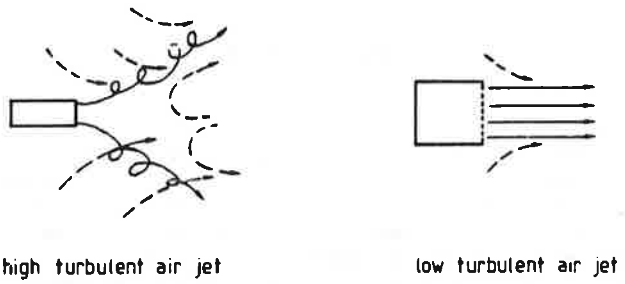

Fig. 1. High turbulent and low turbulent air jets

Three preconditions must be met to create a displacement air flow:

- low discharge velocity
- low turbulence of supply air jets
- a bundle of numerous, adjacent, thin supply air jets.

These preconditions are best met by using a perforated plate or a sieve as an air outlet surface.

Whereas the air outlet velocity with turblent air jets is around 3 - 10 m/s, this is around one power of ten lower for low turbulence air flows.

The turbulent air supply (Figure 2) is used successfully in rooms in which no significant harmful substances are present. Such rooms can be, for example, assembly halls, electronic and mechanical production areas, sewing shops, warehouses. The air outlets create air jets which mix intensely with the room air. This results in a rapid decrease in the jet velocity and the temperature difference between the room and supply air. Adjustable twist outlets are excellent examples of such types of outlet.

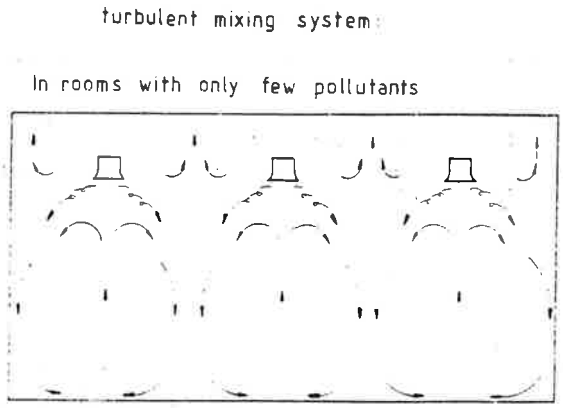

Fig. 2. High turbulent air supply

Radially emitted twisted air jets, which are discharged horizontally from the twist outlet in its basic position, are superposed with a vertically discharged supporting air jet. The share of the air volume flow rate in the supporting air jet can be varied. The outlet is shown in Figure 3, a diagrammatic representation of the supply air jets with different settings of the supporting air jet can be seen in Figure 4. The supporting air jet can be adjusted manually or with a servo-motor.

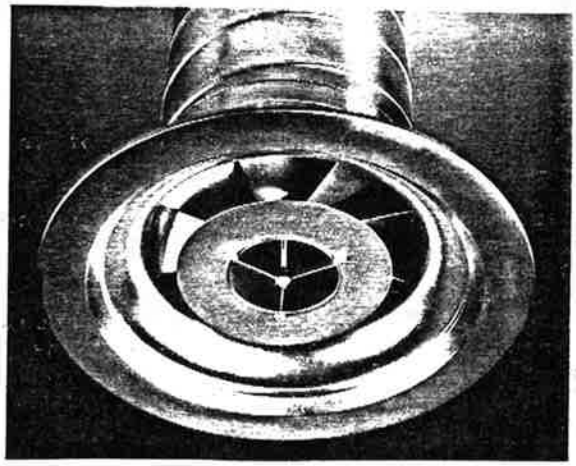

Fig. 3. Variable twist outlet

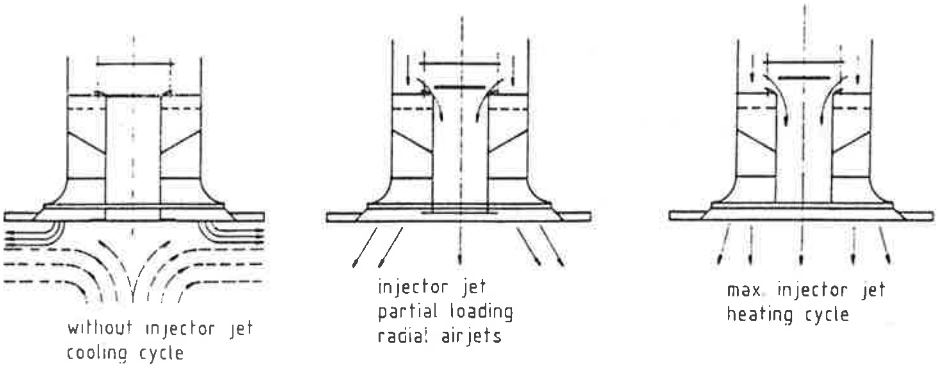

Fig. 4. Jet charakteristics of the variable twist outlet

Figure 5 shows a photograph from a factory workshop with built-in variable twist outlets.

Fig. 5. An industrial hall with a turbulent air supply

Figure 6 shows the temperature distribution in a hall during heating with the twist outlets. The supply air temperature is 27 °C, the room temperature approx. 22 °C. The vertical and horizontal temperature gradient is less than ± 0,5 K. In a heating case, the supply air is discharged vertically from top to bottom. In a cooling case the supply air is discharged horizontally. As can be seen from Figure 7, there are no draughts in the occupied zone. The temperature distribution in a cooling case is also very uniform, with gradients of a max. of ± 0,3 K.

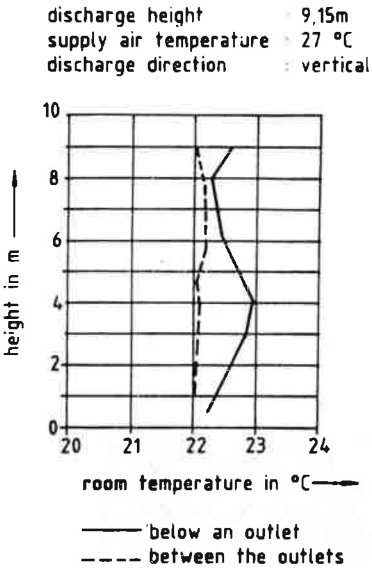

Fig. 6. Heating mode with the variable twist outlet

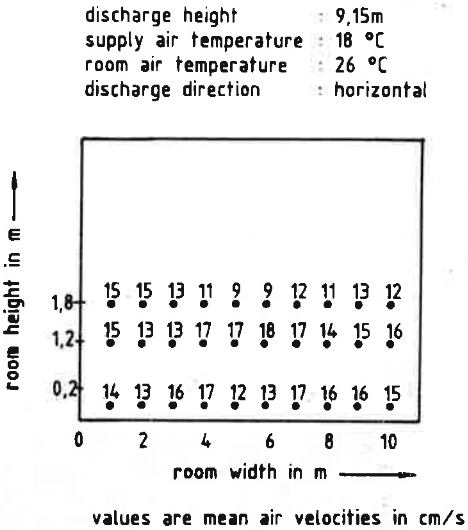

Fig. 7. Cooling mode with the variable twist outlet

Low turbulence air flows (Figure 8) are preferably used in rooms in which significant quantities of harmful substances are released. The air jets display a low induction effect and do not mix so thoroughly with the room air. The spent room air is displaced together with the harmful substances from the occupied zone and carried off as a return air flow. Fields of application are: paint shops, foundries, spinning works, ironing shops, laundries, printing factories etc.

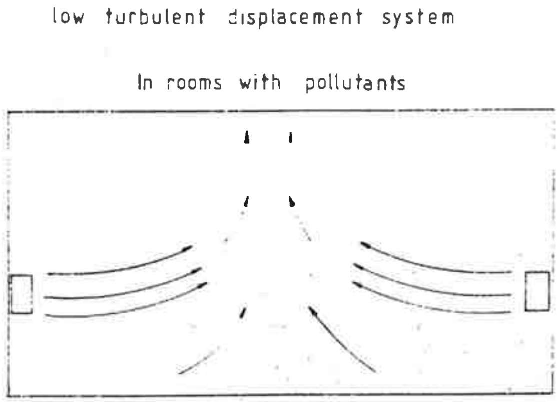

Fig. 8. Low turbulent air supply

Figure 9 shows an example of a low turbulence displacement air flow in an aluminium foundry, and Figure 10 in a spinning works.

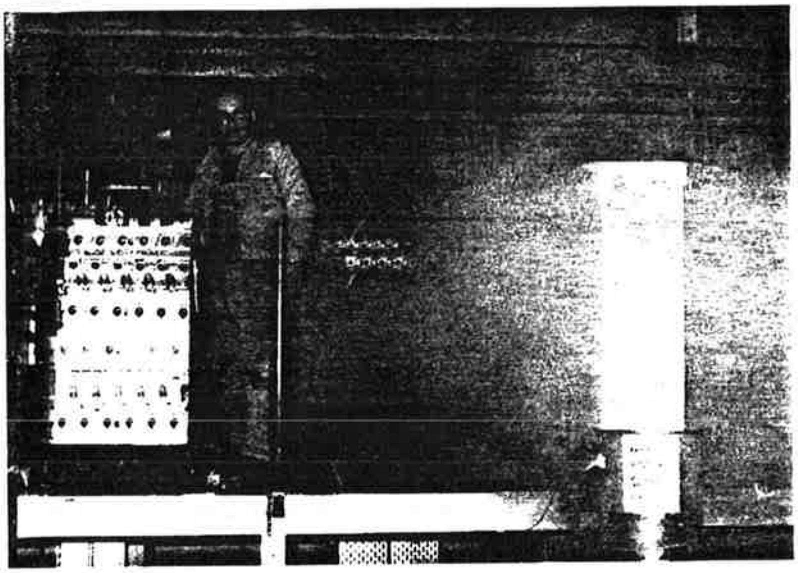

Fig. 9. Low turbulent air supply in an aluminium foundry

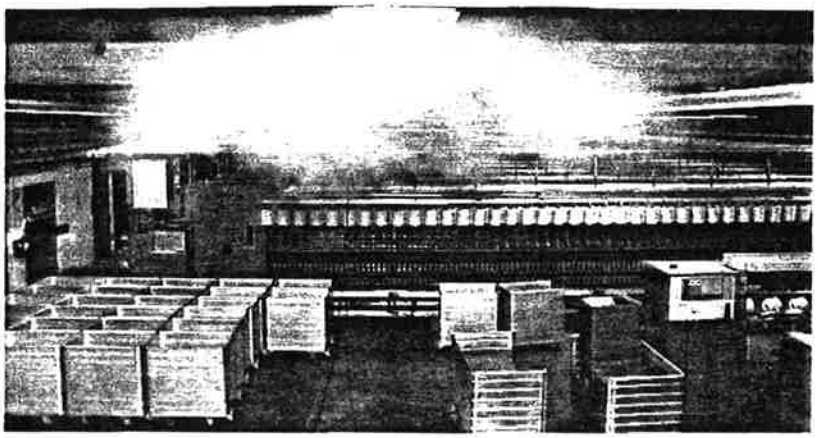

Fig. 10. Low turbulent air supply in a spinning mill

LOCATION OF THE AIR SUPPLY

For the location of the air supply it is important to know how high the thermal load in the room is and whether the harmful substances are heavier or lighter than air.

In the case of high thermal loads (> 150 W/m^2) and light harmful substances the supply air should be discharged near the floor and the return air extracted over the ceiling (Figs. 9 and 11).

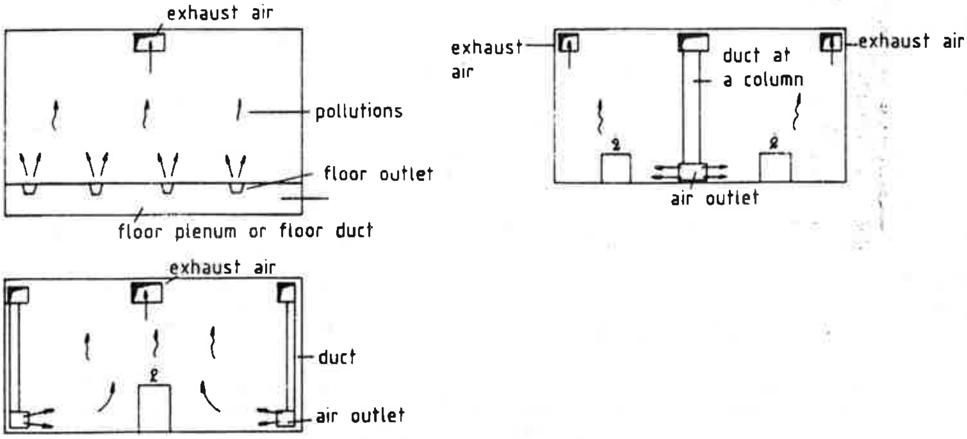

Fig. 11. Air supply from the floor level

With a correct choice of outlets it is possible to achieve a draughtfree movement of air, as shown in the measurement results of Figure 12. These measurements were taken in an aluminium foundry (Fig. 9).

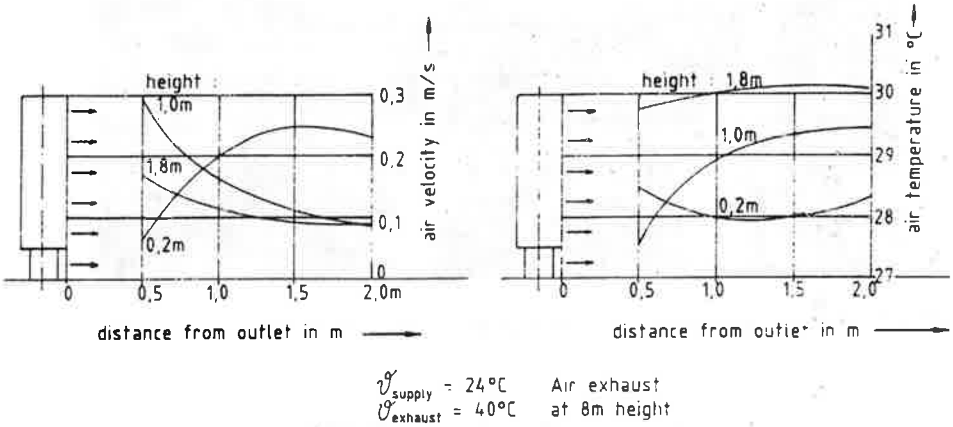

Fig. 12. Air velocities and temperatures at an air supply from the floor level

With lower thermal loads (< 150 W/m^2) or heavy substances the supply air is preferably discharged above the occupied zone. The return air is only extracted at the top of the room if no significant quantity of harmful substance is produced, otherwise it should be extracted from both the bottom and top of the room.

If the supply air is discharged from above then the following holds true: the discharge height must be kept as low as possible so as to bring the supply air into the occupied zone more efficiently and to save energy costs. However, for constructional and technical reasons this is not always possible. In principle, discharge heights between 3 m and 30 m can be realised with adjustable air outlets.

The following principles must hereby be observed: the higher the discharge level the larger the outlet to be used, i.e. the higher the air volume flow rate per air outlet.

A turbulent air supply system in a sewing shop with a discharge height of 3 m is shown in Figure 13, a low turbulence air system in a cutting production with the same discharge height is presented in Figure 14.

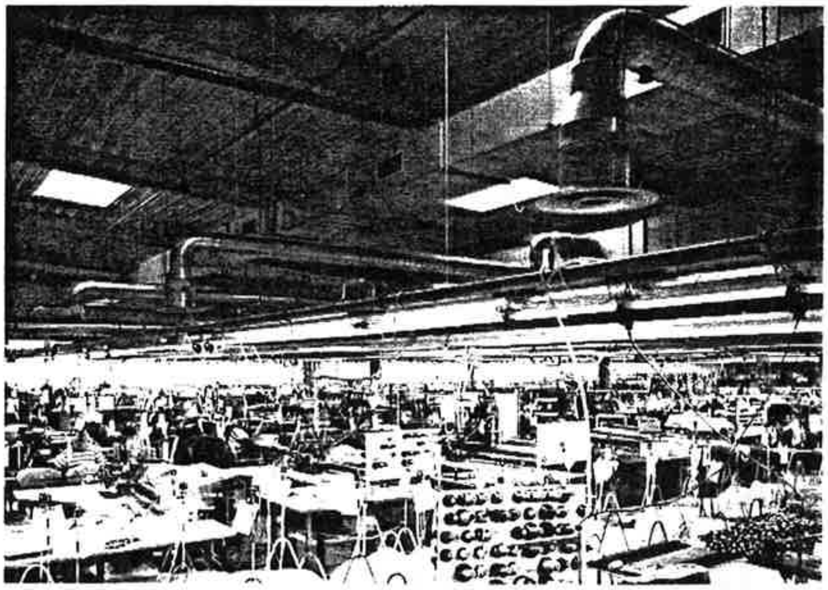

Fig. 13. High turbulent air supply in a sewing shop

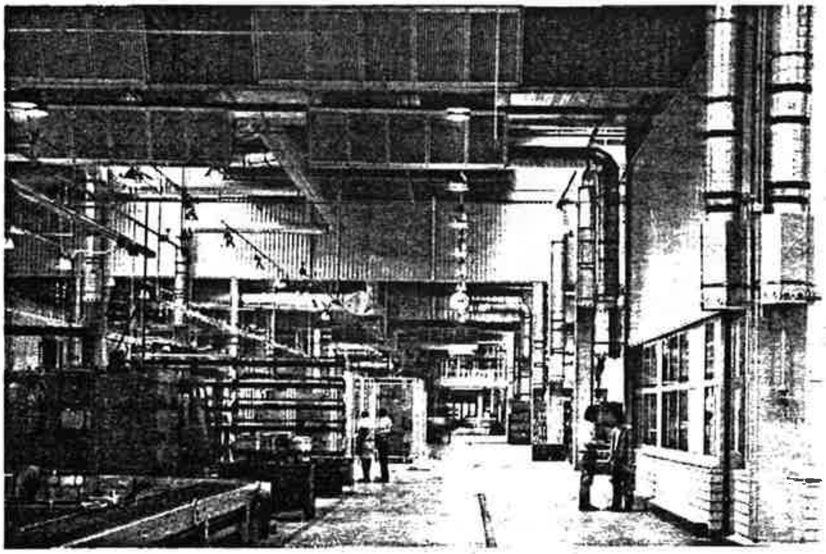

Fig. 14. Low turbulent air supply in a cutting production

Sometimes, air outlets are only desired in the walls or in columns for constructional or operational reasons and the supply air is discharged more or less horizontally over the depth of the hall. Such air outlets are preferably of a swivel design. This allows an optimum setting of the direction of air flow. Air outlets are often used which have air volume flow rates of 2.000 - 10.000 m^3/h and throws of 10 - 30 m. The air outlets can create either turbulent or low turbulence air flows as required. The discharge height should be between 4 - 6 m for air outlets with turbulent characteristics (Figure 15) and 2,5 - 4 m for displacement outlets (Figure 16).

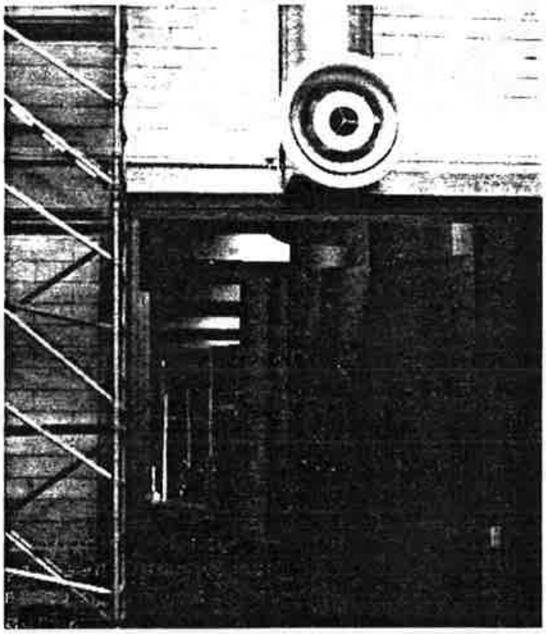

Fig. 15. High turbulent air supply from the wall

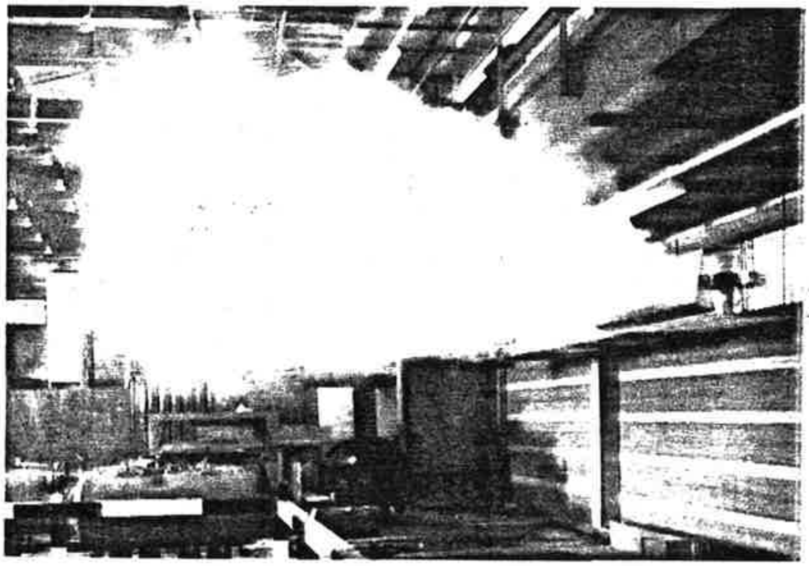

Fig. 16. Low turbulent air supply from the wall

ADJUSTABILITY OF THE DIRECTION OF AIR FLOW

If the thermal load is relatively constant over time it is sufficient in the case of ceiling and wall outlets to set the jet direction optimally during startup and then to leave this unchanged. Because of the only slight fluctuations in the thermal loads the characteristic of the room air flow does not change significantly over time.

If the thermal load is subject to great temporal fluctuations, e.g. cooling load cases in summer and heating load cases in winter, the wall and ceiling outlets are to be fitted with servo-motors which can be used to adjust the jet direction to the thermal load. In principle, the following applies here: the greater the temperature difference between room and supply air, the flatter the supply air should be discharged so as to avoid draughts in the occupied zone. If the supply air is warmer than the room air it should be discharged vertically downwards. With a flat or even horizontal direction of air flow, the warm supply air jets would rise to the ceiling and the occupied zone would be inadequately heated. The servo-motors can hereby be automatically or manually operated depending on the temperature difference between the room and supply air.

Measurements in an 8 m high hall fitted with variable twist outlets at a height of 6 m showed, for example, that with a horizontal jet direction the heating period took 2,5 hours, and with a vertical jet direction only 25 minutes. It can thus be seen that considerable savings can be made in heating costs through an adjustment of the jet direction.

Figure 17 shows a variable twist outlet, Figure 18 a displacement outlet at a height of 26 m in a heating case, whereby the supply air is approx. 10 K warmer than the room air.

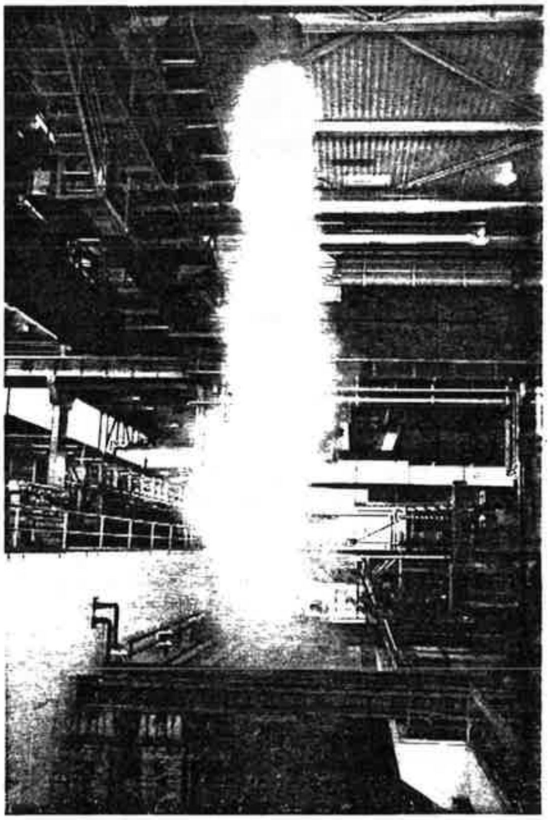

Fig. 17. High turbulent air supply from 26 m height in a heating mode

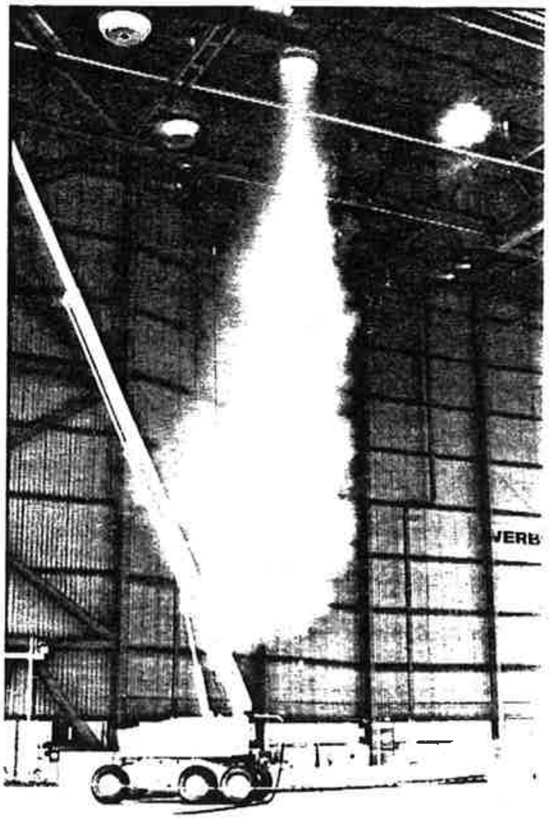

Fig. 18. Low turbulent air supply from 26 m height in a heating mode

AIR OUTLETS TO KEEP INDIVIDUAL WORKPLACES CLEAN

If only individual workplaces are to be kept clean air outlets which discharge the supply air vertically with a low turbulence over a large area above the workplace are ideal solutions (Figure 19). The discharge height should preferably be 2,2 to 2,5 m. In order to avoid draughts air supply velocities of 0,20 to 0,40 m/s are chosen. In order to obtain a stable air jet directed downwards, the supply air must be at least 1 K colder than the room air. In this way, the harmful substances can be forced down to the floor where they are extracted. Figure 20 shows an air outlet in a chemicals packaging department. In this case the system prevents the persons working here from breathing in the powdered substances during packing.

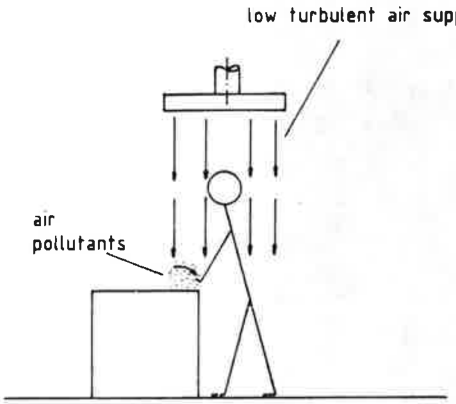

Fig. 19. Protection of individual workplaces

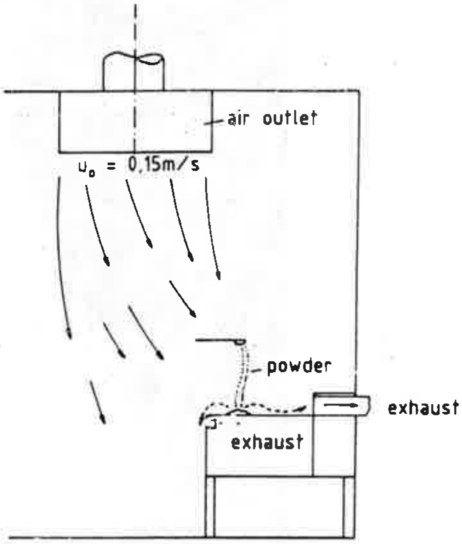

Fig. 20. Air supply in an chemicals packing

Figure 21 shows the air outlets in use to protect a workplace at a triple roller machine to mill pigments. The workplace could also be successfully protected in this case.

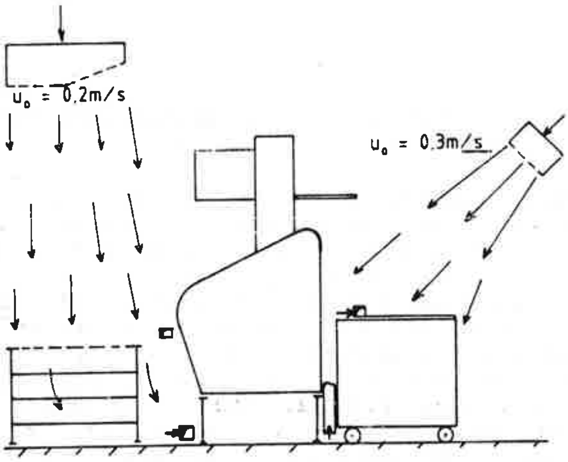

Fig. 21. Air supply in a production of pigments

At workplaces where lead sheets are sawn to produce batteries the concentration of lead dust at the workplace could be reduced to 7% of the original concentration with the air outlet show in Figure 22.

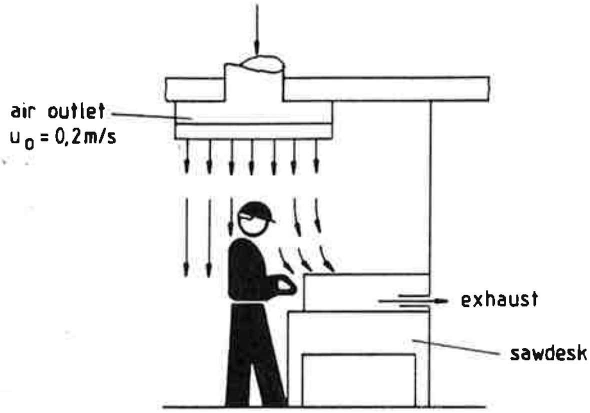

Fig. 22. Air supply at a sawdesk for lead plates

CONCLUSIONS

The choice of air supply system plays a decisive role in the quality and effect of the indoor air flow.

The following principles should be observed when designing the air outlets:

- In halls with no significant release of harmful substances air outlets with a turbulent characteristic are ideal.

- In halls with significant quantities of harmful substances air outlets with low turbulence jet characteristics are preferable.

- In cases of high thermal loads the supply air should be discharged from or near the floor level wherever possible.

- Ceiling air outlets can be used at heights between 3 and 30 m. In principle the lowest possible discharge height should be chosen.

- The higher the discharge height the larger the air outlets should be, i.e. the air volume flow rate per air outlet should also be higher.

- In the case of thermal loads that change in time ceiling and wall outlets are to be fitted with servo-motors so as to be able to adjust the direction of air flow according to the thermal load.

- Harmful substances which are released in the hall are to be extracted directly at the place of their production wherever possible.

- Harmful substances which are mixed with the hall air and which are lighter than air should be forced upwards with the air supply near the floor level and extracted over the roof.

- In the case of harmful substances which are heavier than air the air flow should be from top to bottom.

- If only individual workplaces are to be protected against harmful substances, suitable air outlets are such which discharge the supply air vertically downwards with a low turbulence from a height of 2,2 - 2,5 m and at velocities between 0,2 - 0,4 m/s.