OPTIMUM VENTILATION AND AIR FLOW CONTROL IN BUILDINGS

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Reducing draught problems in the cold working rooms

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SYNOPSIS

This study is done by order of a Finnish air cooler manufacturer and it is founded to a master's thesis of the same subject matter. The company produces e.g. unit air coolers with electric fans and so the aim of the study was to reduce draught problems caused by cold air jets.

The desired values were:

- air throw 50 percent better than before
- draught free working area 30 percent larger than before

Because there are two different ways to reach and maintain low temperatures in cold working rooms we first compare the advantages and disadvantages of both method and then get acquainted with cold air jets and reducing draught problems they can cause.

The cooling coil can be mounted in the ventilating unit in which case the cold air has to be blowed into rooms through ducts and conventional air outlets. Cooling coils can also be mounted directly to the ceiling in cold rooms. In that case there is often used forced convection which is carried out with electric fans. The forced convection improves heat transfer and so it is possible to make coils of compact size. The installation with cooler coils and electric fans is called unit air cooler.

The former method makes it possible to have silent cold rooms with good and even air distribution. The air distribution can be still improved by using porous textile ducts and let the cold air flow through the cloth into the room. However, there can be some hygienic problems. Hygienic problems can be minimised with the latter method, unit air coolers, because they are quite easy to maintain and keep clean. The disadvantage is that there can be some noise and draught problems. Noise problems can be solved by using fans with low RPM, but the draught problem still remains. It can be reduced with air deflectors which intensify the so-called Coanda effect. The results of this study are utilised in a novel series of air coolers.

1. COMPARISON OF THE COOLING METHODS OF COLD ROOMS

As already mentioned, in practice there are two basic methods to make cool and maintain low temperatures in cold rooms: cooling coil (evaporator) in the ventilating unit or directly in the cold room. If the cooling coil is mounted in the ventilating unit the cold air has to be distributed into rooms through ducts. If it is mounted separately in the cold room there are two alternative manners to handle the cooled air: it can simply be blowed into the room with fans or there can be textile ducts or perforated sheet metal ducts which give good air distribution with low air velocity. In this report we classify the ventilation units with cooler and unit air coolers with ducts into same group and unit air coolers with deflectors into their own. So we can compare the two groups to each other.

1.1. Air distribution with ducts /1/

These solutions have the following advantages:

- even distribution of cooling effect
- good air mixing (especially with textile ducts or perforated sheet metal ducts; air can also be distributed through ordinary supply air outlets)
- possible to limit fan noise region outside of the working area (especially with the ventilation unit + cooler)
- possible to direct the cooling effect to limited region

There are also some disadvantages:

- the water condensation risk (with sheet metal ducts and non-porous, perforated textile ducts)
- the risks of bacteria (porous textile ducts)
- increased need of fan power
- location constraints caused by form and size of the ducts (Figure 1).
- cleaning of the ducts

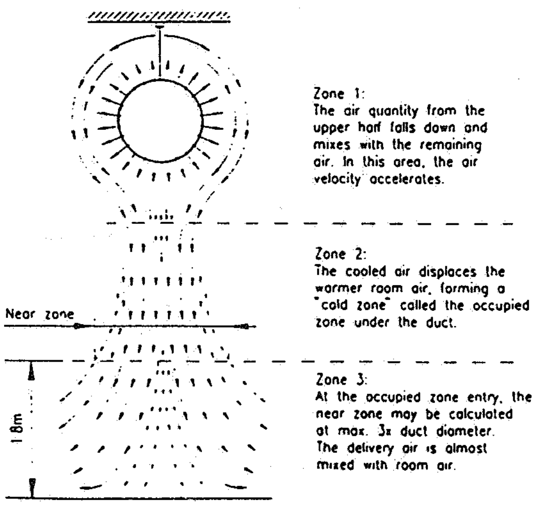

Figure 1 /2/

It is important that the considered face velocity is not exceeded because the air velocity rises beneath the duct due to the temperature difference. The maximal air velocity can be 2.5-4 times as much as the face velocity when the temperature difference is 4 K. So there should not be used big temperature differences due to the small air mixing between surroundings and delivery air. The picture included visualises air flow beneath a textile duct. /2/

1.2. Unit air cooler with deflector /1/

When using unit air coolers (cooling coils + fan), there are advantages as follows:

- possibilities to adjust the air throw with deflectors and achieve desired air circulation
- the deflectors can be adjusted after the cooler installation so that the air throw can be readjusted when the needs have changed
- easy to maintain and keep clean = less bacteric problems

There are some restrictive factors which should be known when designing a cold working room with these coolers intending to avoid draught problems, e. g. attention should be paid to constructional things such as beams and lighting fixtures because they can turn air jets and get them to the occupation zone too early.

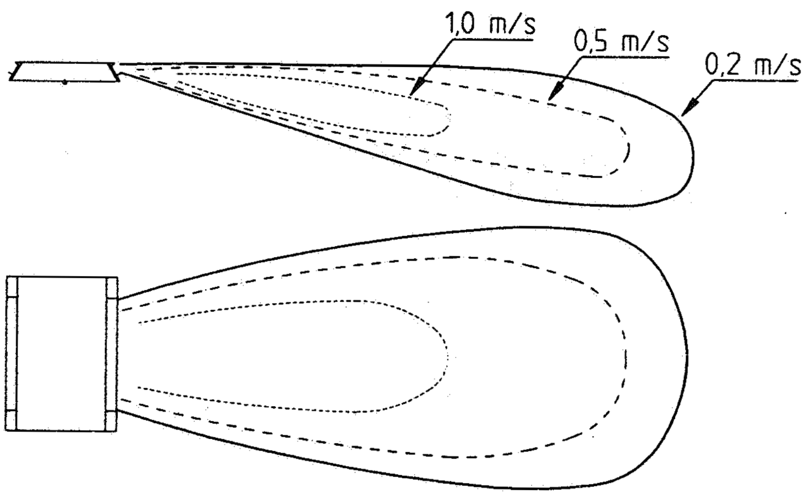

Figure 2. Unit air cooler with deflector.

2. THE COANDA EFFECT

When an air jet is blowed parallel with a wall or ceiling it will seize to the surface if the air outlet is near enough. This can be explained with the Bernoulli's law: the sum of the dynamic and static pressure is constant, so, the higher is the dynamic pressure (due to the air velocity) the lower is the static pressure. So, when comparing the air jet and surroundings there is a difference between the static pressures. The pressure difference makes air flow in the direction of the lower pressure. This causes surrounding air to mix to the jet. When the air jet is flowing near a surface the mixing is possible only on the free side of the air. It can also be imagined that when the force caused by the pressure difference is bigger than the opposite directed force caused by the differences of air density the air jet keeps to the ceiling; when the velocity lowers so that the pressure force is lower than the density force the jet begins to bend downwards and then the jet loosens from the ceiling. The distance between air outlet and the loosening point can be estimated with the equation

$$x = d_e \cdot 0.63 \cdot \frac{K}{[K_\Theta \cdot Ar]^{1/2}} \qquad (1)$$

where

x is the distance between air outlet and the loosening point
d_e is diameter of the air outlet
K is an air throw coefficient
K_Θ is a temperature coefficient

It is also known that the Coanda effect doesn't exist when the distance between air outlet and the ceiling is more than 300 mm. However, it can be put into effect by directing the jet slant towards the ceiling surface.

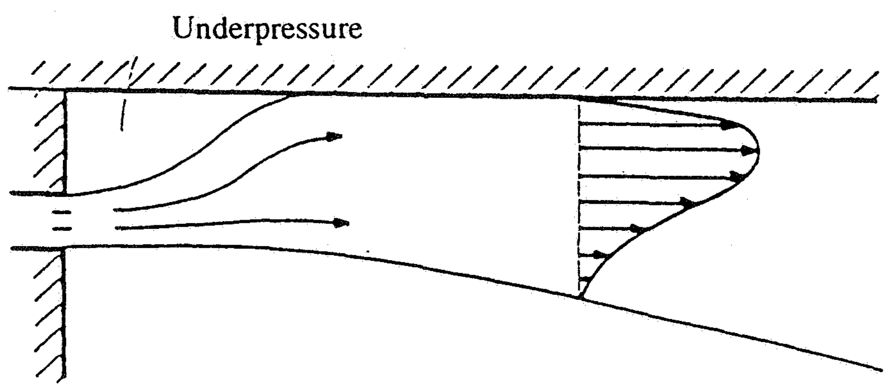

Figure 3. The Coanda effect.

3. THE NEW SERIES OF UNIT AIR COOLERS

Figures 4 and 5 present an air cooler from the new series. Note the air deflector with constant angle on the lower edge of air outlet and adjustable deflectors in the outlet. The cooling capacity output values cover an area of 4-48 kW and numbers of fans are 1-4. The deflectors make it e. g. possible to compensate the influence of distance between the cooler and ceiling. If the distance is long, then the jet can be directed up towards the ceiling and make the Coanda effect work.

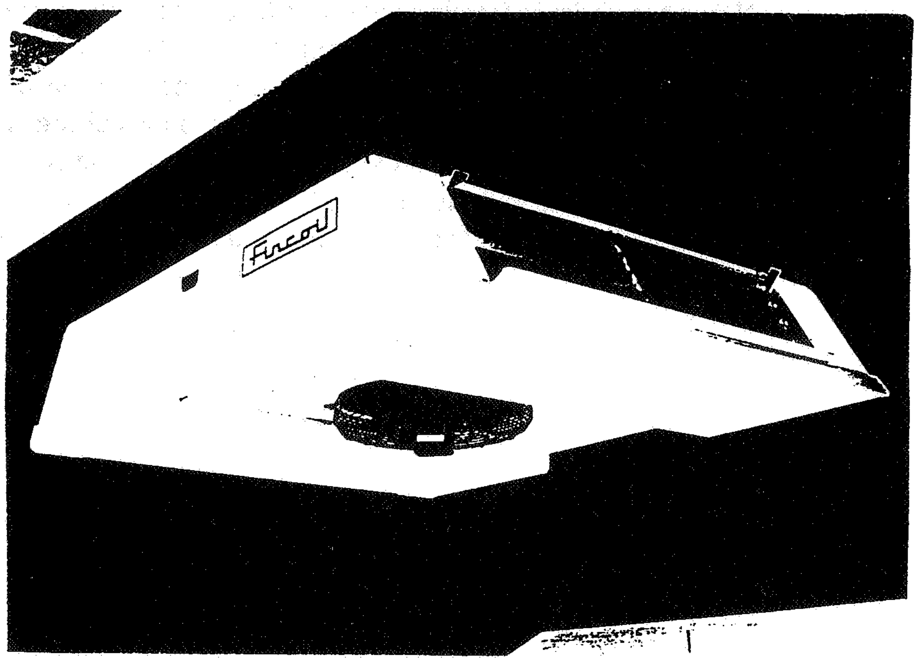

Figure 4. Polar Bear Duo - a new air cooler

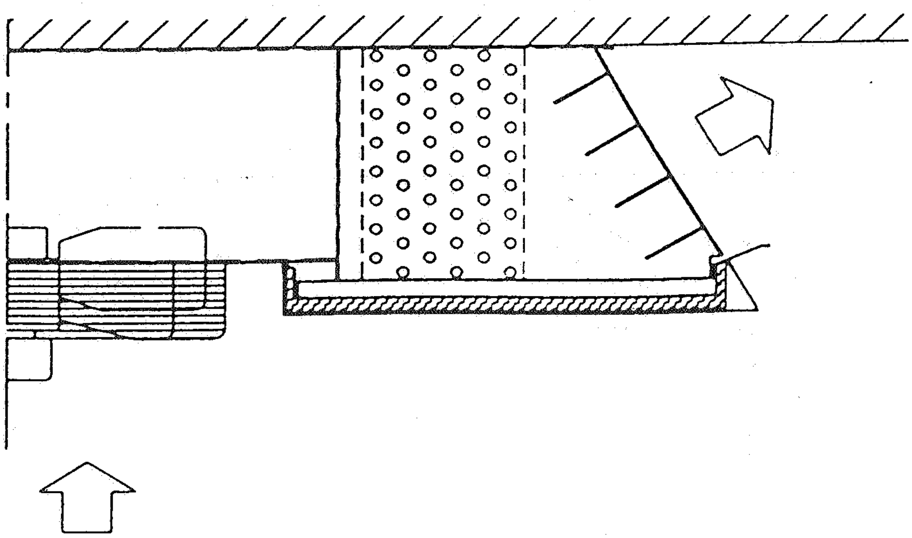

Figure 5. Cross Section of the Polar Bear Duo. Note air deflectors in the outlet.

4. SOME HINTS TO COLD ROOM LAYOUT

When the cooling is proposed to carry out with this kind of coolers the correct positioning of them is as important as it will be when using porous or perforated ducts as air distributors. Wrongly selected and positioned coolers can cause serious draught problems and make the workers complain about it.

First the air throw of the desired air velocity should not be longer than the distance to the opposite wall. This can cause draught near the wall. If the air flow is insufficient with suitable air throw there should be chosen a larger device if the smaller one can not be positioned better. As we know, the air flow (m^3/s) is the air outlet area multiplied with air velocity, so the larger is the area the lower is air velocities we need. This leads to shorter air throw. (Figure 6.)

Second the coolers should not be installed as the Figure 7 shows. The air jets will make each other to bend steeply to occupied zone. A better way is also shown in the same picture.

Third there should not be any beams and light fittings so that they can disturb the air flow. Instead of this the coolers have to be positioned so that air jets flow parallel with the beams and lamp boxes. Figure 8.

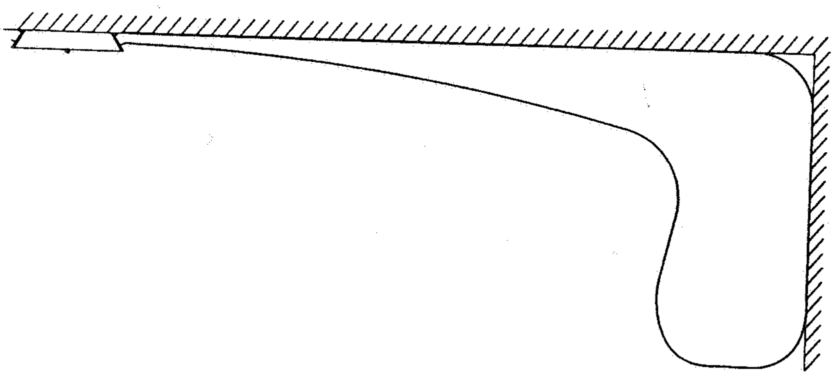

Figure 6. The air throw is too long to this room.

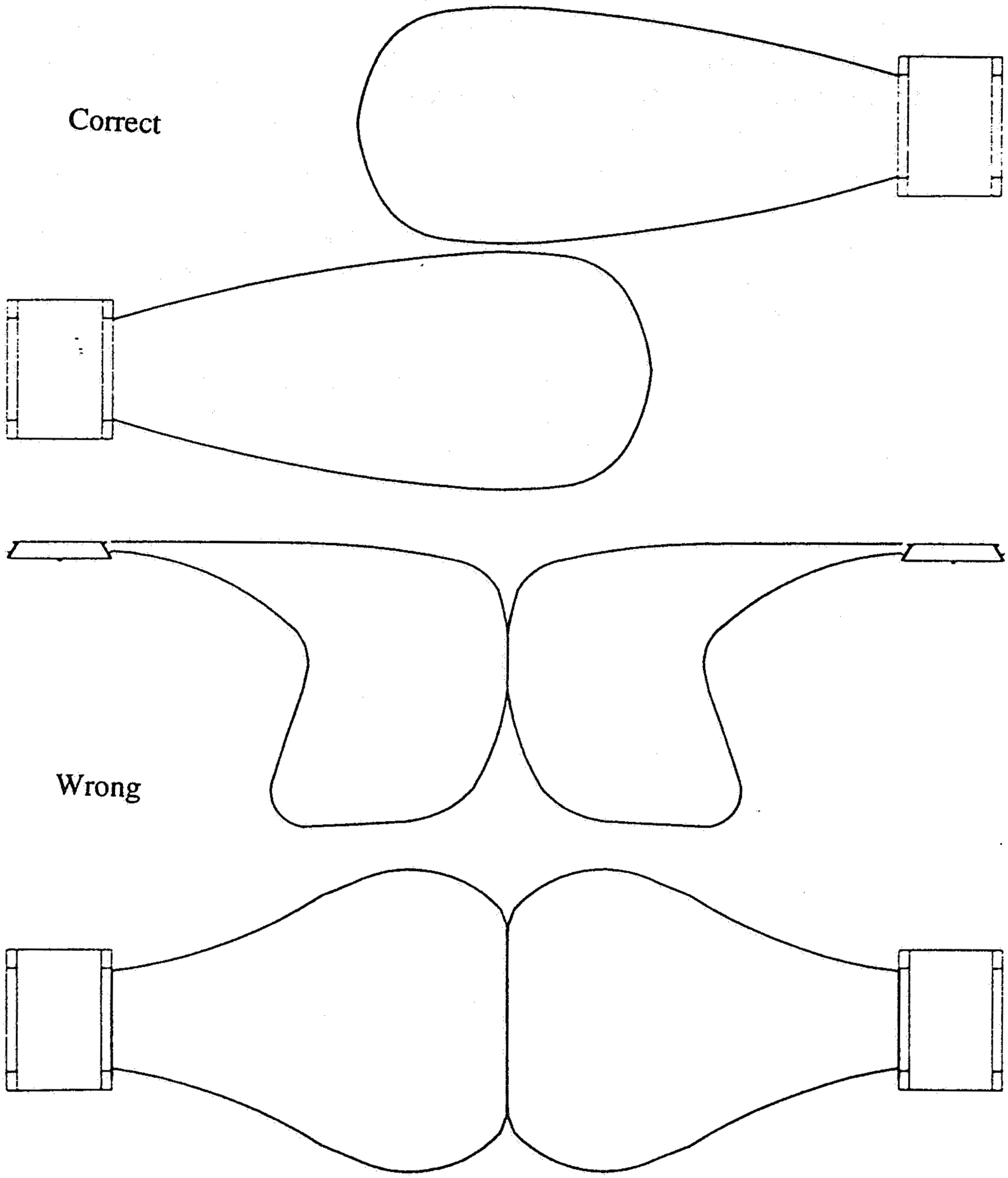

Figure 7. Correct and wrong manners to locate air coolers.

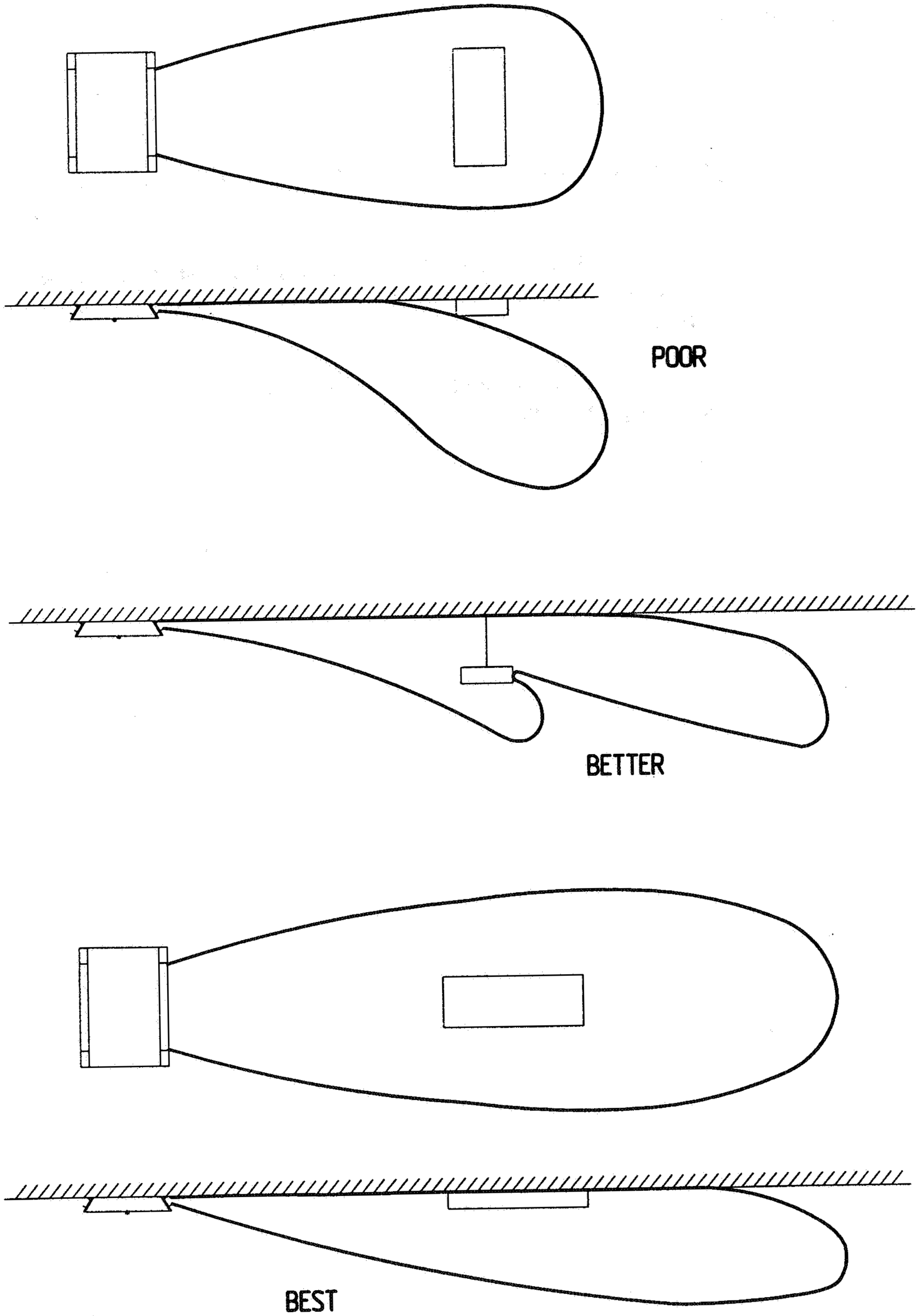

Figure 8.

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