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Digital Transmission of Climatic Data from Underground to Surface

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Recent experience has shown that all underground workplaces in the Campine Coalfield in Belgium will require controlled cooling within three years. Considering the socio-economic and legal importance of the climatic problems underground, IREA has undertaken studies in forecasting the climate of future workplaces, planning the necessary cooling equipment and optimizing efficiency in the existing cooling equipment.

These studies are being carried out using the climate forecasting program of Bergbau-Forschung. So far, the German model has been obliged to utilize manually measured data from a few workplaces in the Campine. As the model does not fit very well with these measurements, it has been thought necessary to develop a system of continuous data acquisition and transmission. This system is being tested in the Beringen mine of the N.V. Kempense Steenkollenmijnen.

In the first part of this paper the digital tranmission system is described; in the second the sensors used to collect the necessary climatic data are presented, and in the third some results are given.

Introduction

Improvements in underground climate forecasting require the accurate reading of the necessary data in a sufficient number of workplaces in the mine (development works, coalfaces and gateroads) in order to constitute a representative sample for the entire coalfield, in this case the Campine Coalfield in Belgium.

These data include :

- the dry and wet bulb temperatures at both ends of the circuit and in some well chosen intermediate spots (for example, the inlet and the outlet of a cooler);
- the virgin rock temperature;
- the air flow rates;
- the length and the section of the workplace;
- the advance rate;
- the run-of-mine output;
- the nature of the surrounding rocks and their thermal properties;
- the nominal capacity of the sources of heat or cold, etc.

Data fluctuating in time are recorded in order to obtain accurate averages. The measuring techniques must reach a higher degree of accuracy than the standards in force for monitoring. The data are processed with appropriate computer and statistical aids according to the standard methods and are used afterwards to draw up a catalogue of all the parameters included in the climate forecasting program, for example λ_{eq}, the equivalent coefficient of heat conduction and η_f, the coef-

ficient of humidity.

Transmission system for measured data

For the transmission and storage of data on ventilation and climate, the digital transmission system ZM 400 of Funke & Huster was selected. It was found to satisfy in the best way the imposed requirements :

- to store both digital and analogue information from about ten channels for a comparatively long time (from a few days to one week), the data being called for at a frequency ranging from one minute to about ten minutes;
- to operate autonomously so as to be able to cope with interruptions of the signal registration in case of defective network connection;

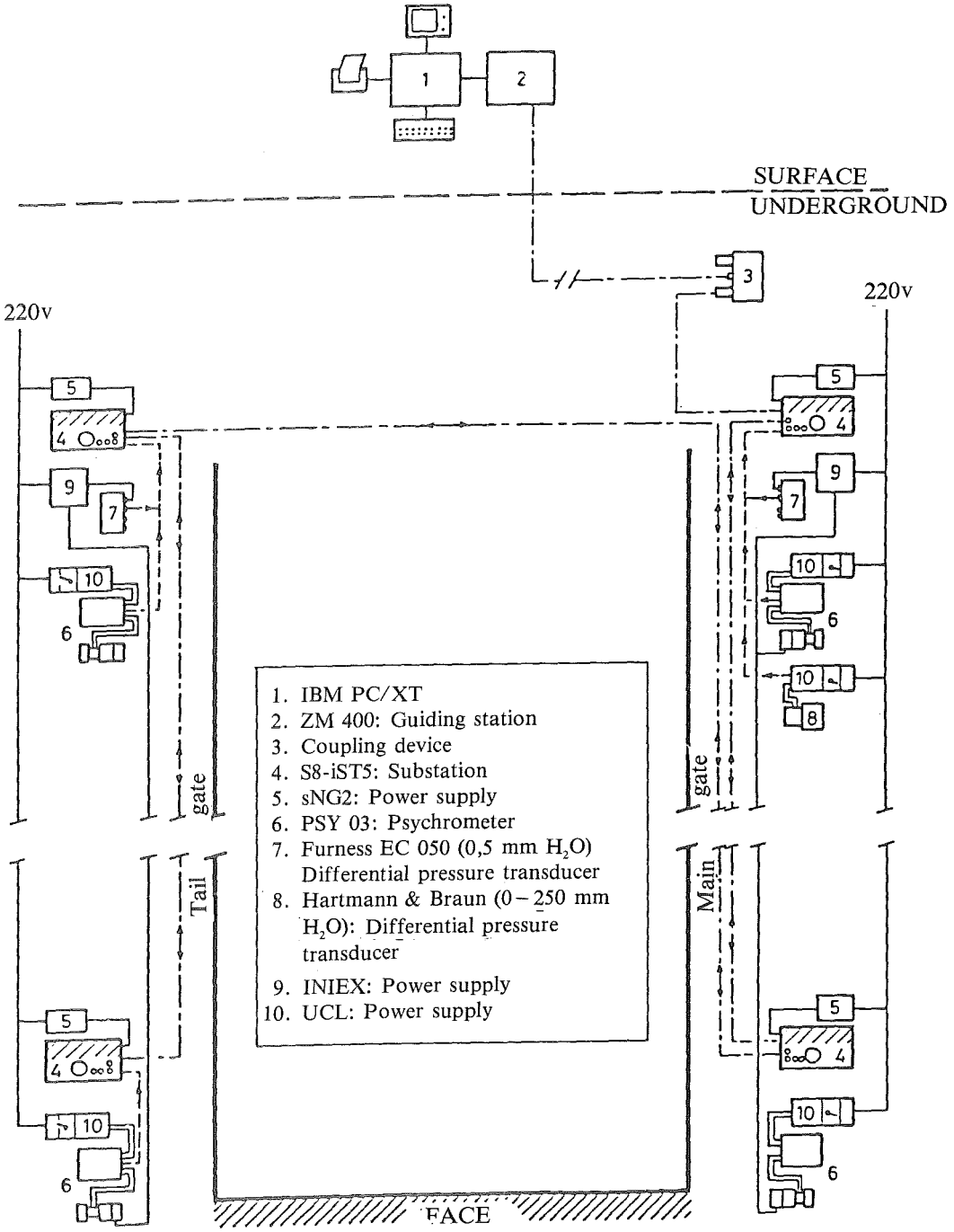

FIGURE 1. System configuration

- to offer mechanical resistance to the environmental conditions in the mine;
- to be provided with a certificate of intrinsic safety.

Furthermore, this system is modularly designed so that it can be extended very easily.

System hardware

A block diagram of the transmission system that was installed and tested in the mine of Beringen is shown in Figure 1.

The system consists of five groups of items :

- an IBM PC microprocessor;
- a ZM 400 guiding station;
- a coupling device;
- S8-iST5 substations;
- sNG2 power supplies.

The IBM PC-XT configuration contains a system unit PC-XT with 256 KB memory, a hard disc of 10 MB, a diskette drive of 360 KB, a colour screen, a keyboard, a screen and a printer adapter, a RS 232 asynchronous adapter, a Megaplus II card with 256 KB memory and a printer.

The most important task of the IBM PC is the filing of the measured data received every four minutes by the guiding station ZM 400. Moreover, the IBM PC enables the use of the application software and the filing of data simultaneously.

The ZM 400 guiding station is equipped with a power supply, a 1200 Baud modem, a guiding processor, a memory card and a central unit. Every four minutes, this station calls the four substations cyclically and routes all binary and analogue measured data with time and address information onwards to the filing station. Figure 2 shows the guiding station installed on the surface

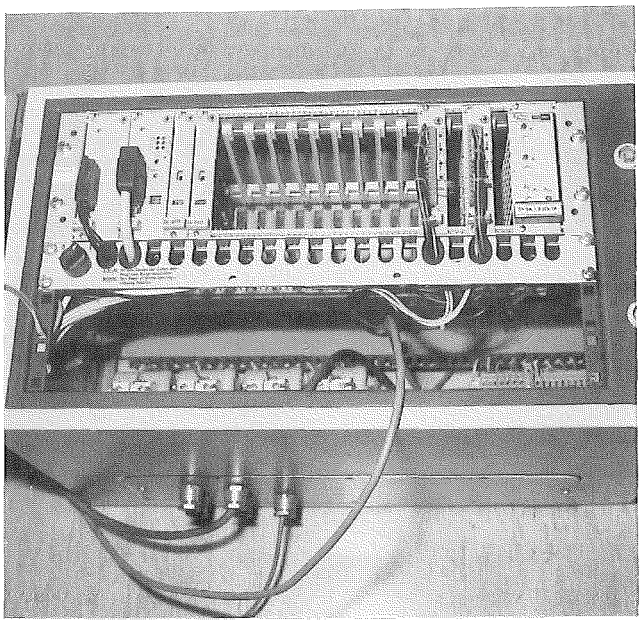

FIGURE 2. The guiding station with opened cabinet

with opened cabinet.

The coupling device links the non-intrinsically safe surface equipment with the intrinsically safe underground equipment.

Each substation S8-iST5 is equipped with a 1200 Baud modem, a central unit, a voltage stabilizer, a power supply for active input, an analogue input card (6 x 0-10V) and a binary input card (1 x 8 Bit).

The measuring devices (psychrometer, differential pressure transducer and others) are connected to the substations, two of which are installed in the main gate and two in the tail gate. Moreover, each substation is equipped with five selector switches connected to a digital input card in order to add the necessary information on the measuring conditions.

The current for the substations is supplied by a sNG2 power supply. The input tension of these supplies is 220 V AC (Sch)e, and the output tensions are + 5 V DC and + 12 V DC (Sch)i.

Figure 3 shows the substation and

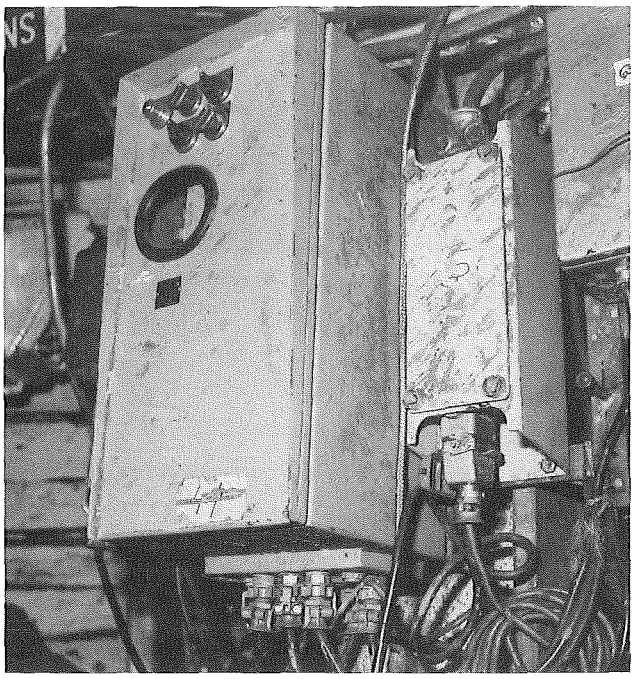

FIGURE 3a. Substation and power supply

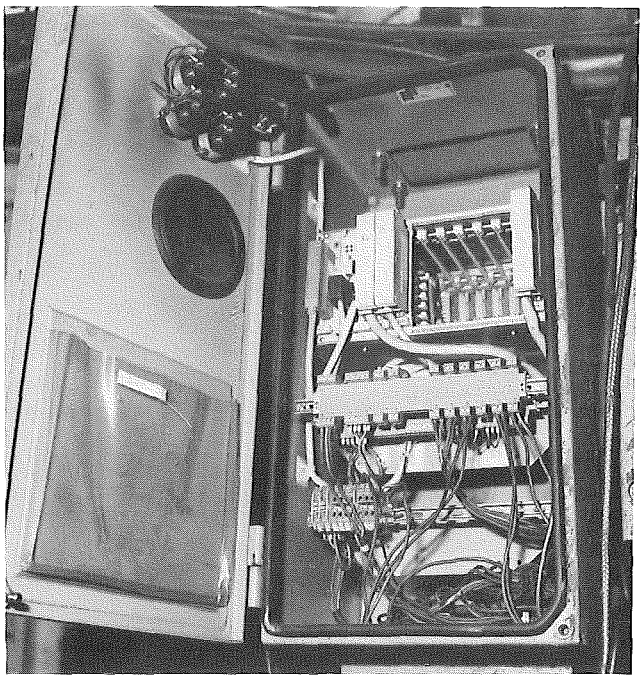

FIGURE 3b. Substation with opened cabinet

the power supply.

Software overview

System software

With regard to the operating software of the IBM PC, the CONCURRENT CP/M-86 from Digital-Research was chosen. This multitask system enables one user to handle several programs quasi-simultaneously.

User software

The user software contains the following items (Figure 4) :

- Interface software in order to link IBM PC with the guiding sta-

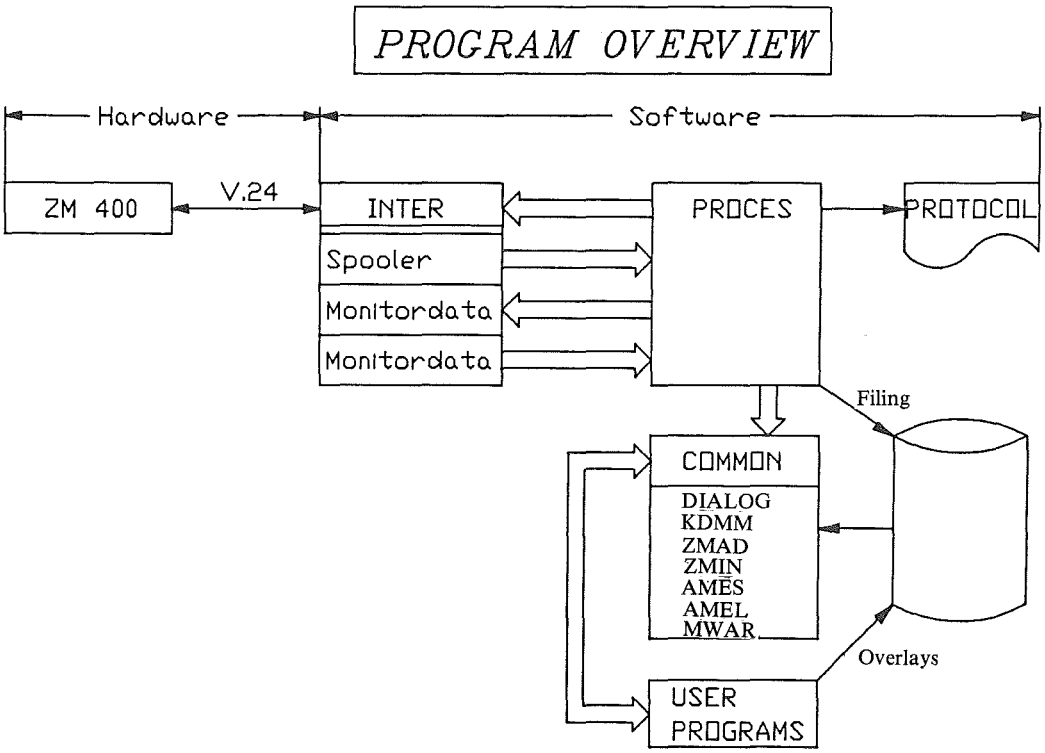

FIGURE 4. Software program overview

tion.

- The acquisition and the processing of signals and measured data.
  The information is sent through pulse code modulated telegrams from the guiding station to the substations over a maximum distance of 20 km. The data transmission between the stations occurs half duplex through a 4 wire cable. The configuration of the telegrams, as shown in Figure 5, ensures a high reliability of transmission : each telegram is secured with a Hamming distance D = 4, which means that in each telegram up to 3 wrong bits are recognized in the receiving station. In this case the telegram's contents are rejected and alarm is given.
- A filing program to stock the measured values in a ring archive.
- An interactive program to facilitate the dialogue between man and machine.
- A program to transmit system and process commands.
- A program to modify the system configuration.
- A program to display or to print the measured data.

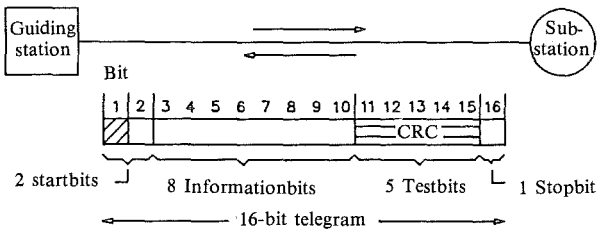

FIGURE 5. Telegram configuration

Sensors

Measuring the airflow quantity

The method is based on the measuring of the pressure drop Δp, which is related to the flow quantity Q by the well-known law $\Delta p = kQ^2$, where k

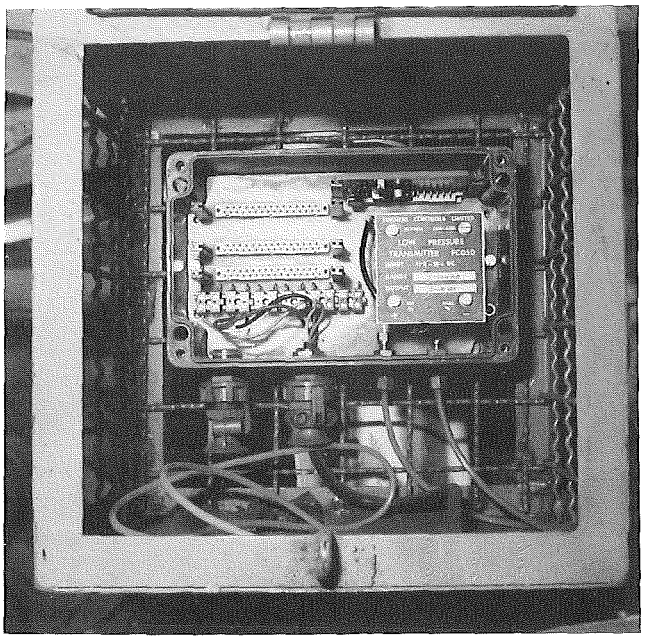

FIGURE 6. FC 050 Pressure transducer

is the aeraulic resistance value of the duct through which the flow occurs, assuming that the Reynolds' number is large enough.[2,3]

Nowadays, high sensitive pressure transducers appropriate to industrial environments are available. Figure 6 shows the FC 050 pressure transducer, manufactured by Furness Controls Ltd., U.K. This transducer is of the diaphragm capacitance type. With this method the flow quantity can be determined with a maximum error of 2%.

Measuring the dry and wet bulb temperature

For twenty-five years IREA has been measuring air humidity with the psychrometric method.[4] To this end, the Institute has developed a psychrometer provided with a small electric ventilator to ensure a continuous air circulation. This apparatus is shown in Figure 7.

Measuring the electric power

As there is no intrinsically safe apparatus to measure electric powers directly, this measurement is

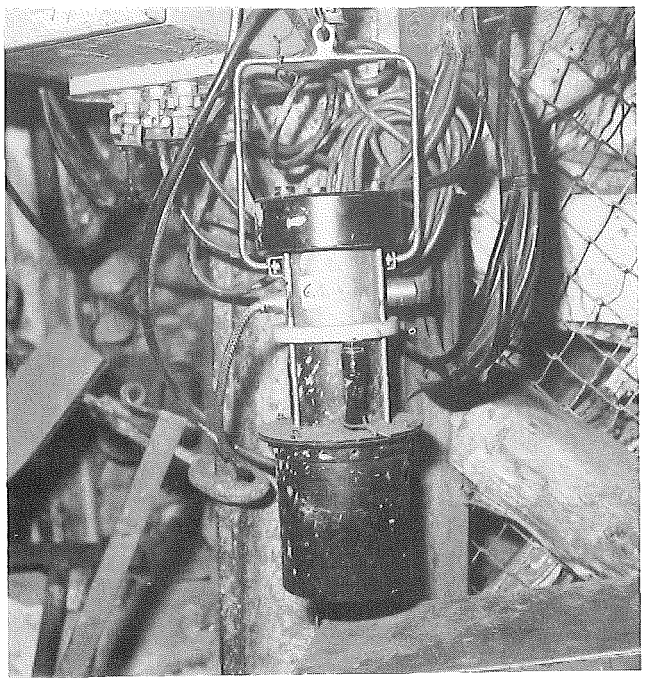

FIGURE 7. Psychrometer

done in an indirect way.

The current consumption of the electric installations is measured continuously. On the basis of the registration of the average tension and the average cos ϕ of the whole mine, the power can be calculated with sufficient accuracy. Figure 8 shows the transformer with the current transducer.

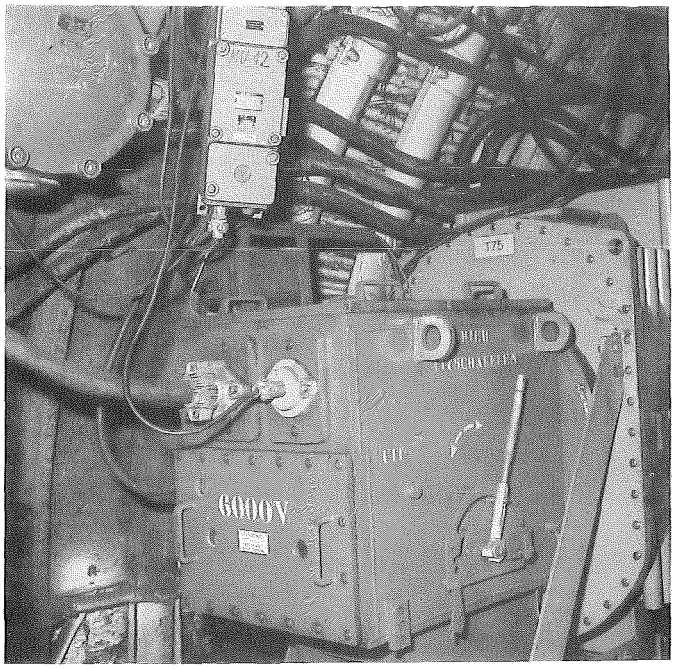

FIGURE 8. Transformer with current transducer

Results

Preliminary results are summarized in Figure 9. On the temperature and the current consumption graphs shift changes and worked/non-worked shifts are clearly visible. The temperature path at the end of the tail gate corresponds perfectly with the current consumption, when a few hours' delay of the changes in temperature versus these in current consumption is taken into account. Repeated controls by manual measurements show that the obtained accuracy lies far above the standard required for monitoring.

Conclusion

This new digital transmission system enables one to take the maximum advantage of the climate forecasting program of the Bergbau-Forschung, in order to plan the necessary cooling equipment in future and to optimize the efficiency of existing equipment.

Acknowledgements

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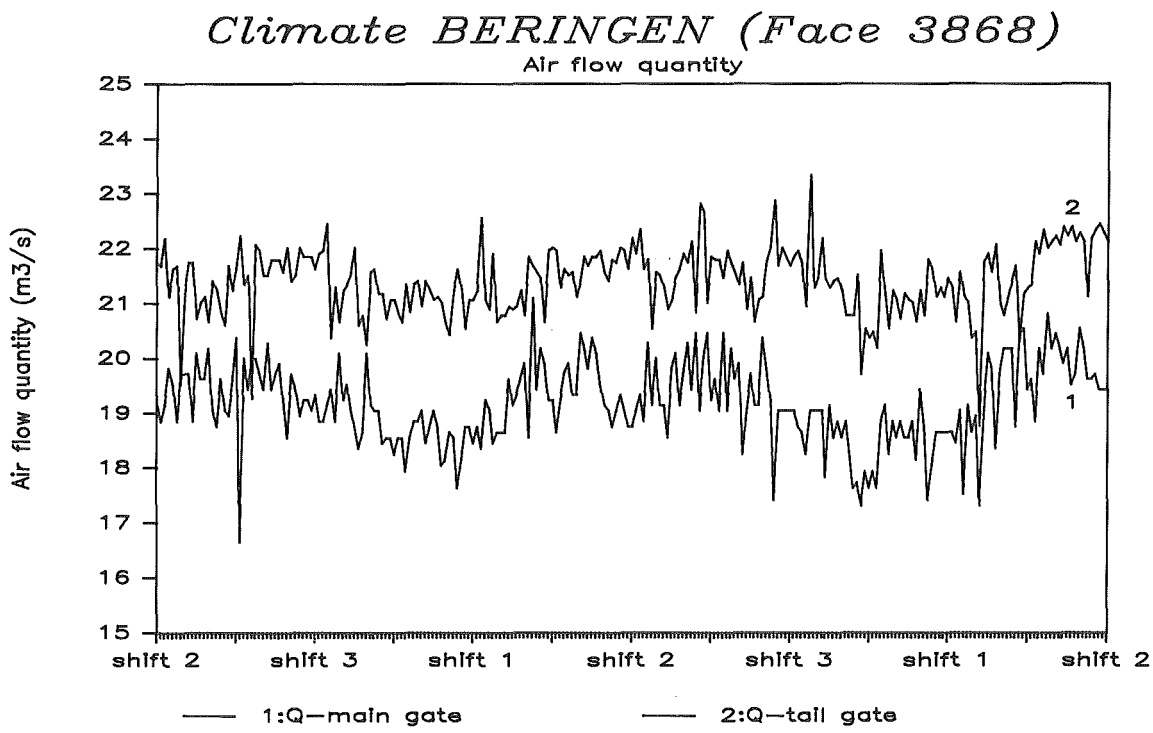

FIGURE 9a. Measuring results: Air flow quantity

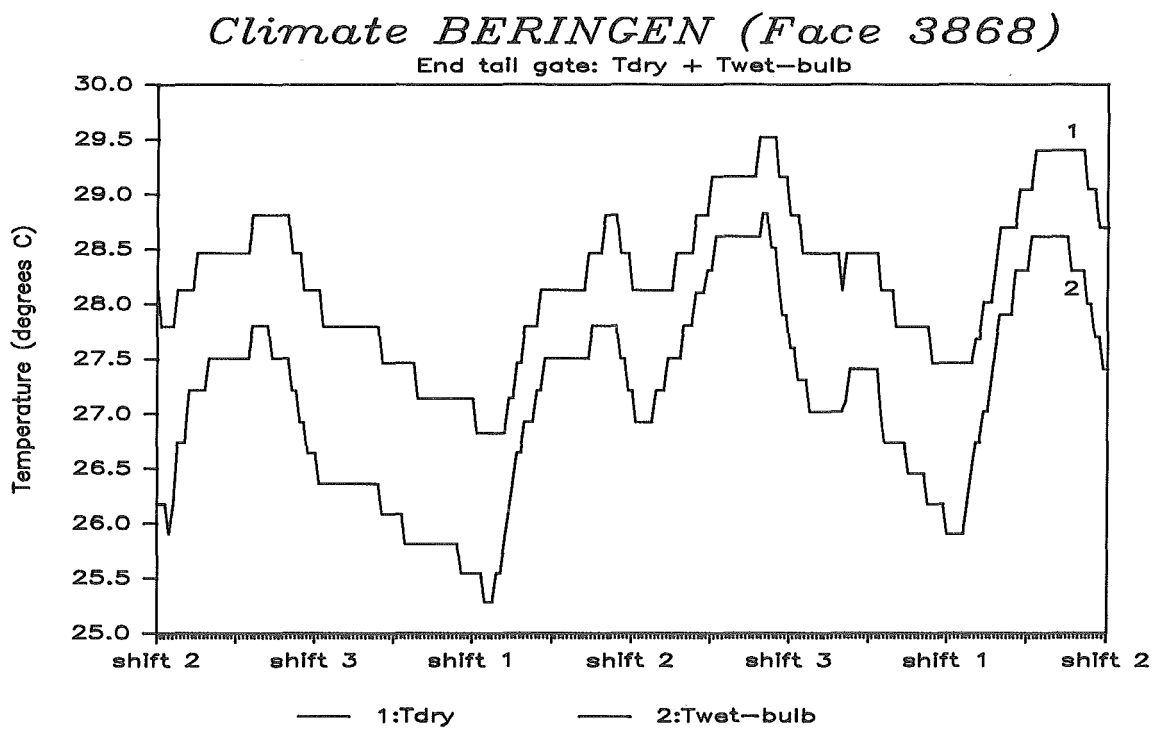

FIGURE 9b. Measuring results: Dry and wet bulb temperature

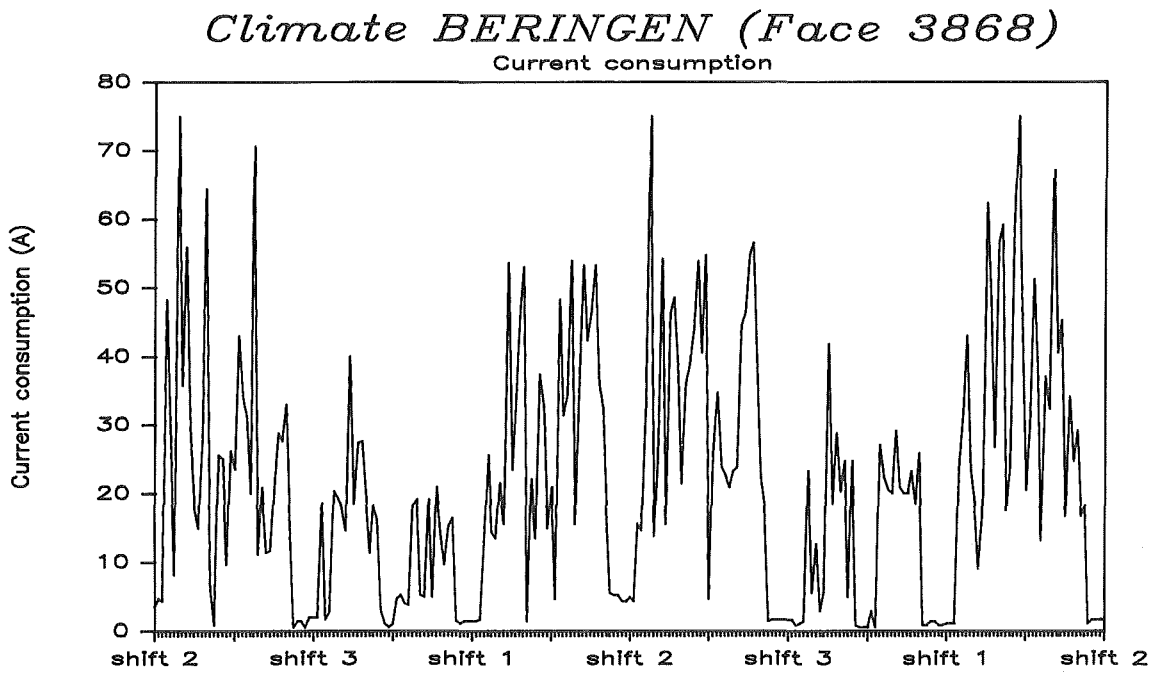

FIGURE 9c. Measuring results: Current consumption

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